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Nursery & Market Garden Industries'
- Development Society, Limited -

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Introduction.

VICTORY year found the Research Station continuing its investigation of food crops in houses which had been repaired after the flying bomb damage of the previous season. The work had been slow and glazing was not completed until the end of January. In consequence difficulties were expected owing to the over-wet and cold condition of the soil. Steps were taken to remedy this as much as possible, and the resulting crops were reasonably good. Shortage of labour became more pronounced than at any time during the War owing to the difficulty of securing assistants from the Women's Land Army to replace those who resigned from that excellent organisation.

Current Investigations.

The experiments commenced in 1940 to study the relative effects of muriate and sulphate of potash upon the tomato crop have been continued. The crop yield was similar in each case being 61.52 tons per acre as the average of the sulphate plots and 61.41 tons per acre from the muriate plots. Thus the use of muriate of potash in quantities equivalent to the normal applications of sulphate of potash continually during the past five years has produced no harmful effects on our soil, when used in conjunction with our methods of cultivation, including winter flooding.

The effect of applying a complete base fertiliser after steaming was again compared with that of an application of sulphate of potash only. This year the crop yields were identical, namely 51.9 tons per acre.

The experiments of adding flowers of sulphur and of treating the soil with sulphuric acid were repeated, and there was little difference either in crop yield or general habit between the plants grown on these plots and in the controls, except retardation of early growth after applying sulphuric acid.

The cultivation of tomatoes and carnations in gravel moistened with a water culture solution was replanned because the previous crops were destroyed by the flying bomb. Unfortunately disease gained entrance to the cultures and being pumped round in the circulating solution it spread rapidly until practically every plant was affected.

Tomatoes were grown for the sixth year in cucumber houses by the roof crop method, with the usual satisfactory result. Variety trials have been continued both with leafmould resisting types and the ordinary varieties.

Owing to the damaged glasshouses it was not possible to grow lettuce during the winter.

The investigation of *Verticillium* wilt of the tomato has been continued and extended to the cucumber. Tomatoes inoculated with *Verticillium albo-atrum* and kept under conditions normal for tomato growing wilted badly. Similar plants in a closed chamber where the temperatures and humidity were higher did not wilt and the fungus made very little progress in the plants. *Verticillium dahliae* caused approximately the same amount of disease under both sets of conditions.

Potentate plants inoculated with *V. albo-atrum* and kept standing in pans of water developed the disease to the same extent as those receiving normal watering and those kept as dry as possible. With *V. dahliae* also very little difference in the severity of the disease was noted.

Verticillium albo-atrum was isolated from cucumbers suffering from wilt. Experiments showed that the cultures isolated would infect tomatoes and vice-versa. The severity of the disease appears to vary with the temperature, plants inoculated in September being severely crippled while those inoculated in June were less severely affected. It was found, however, that cucumber plants wilted under conditions which checked the disease in tomatoes.

Cucumbers inoculated with *V. dahliae* in June remained healthy but in September several plants became infected. The only symptom was slight stunting of the growth but the fungus was re-isolated from the tissues.

Investigations of the stem rot of tomato caused by *Didymella lycopersici* have been continued. It has been shown that the attack was more severe where plants were grown in soil which had been steam sterilized before inoculation than in a similar soil which had not been sterilized before inoculation. The spread of the disease by air-borne spores has been demonstrated. Spores have been found in the air within the glasshouses and in the open during the winter months after the crops have been removed.

Attempts have been made to control the disease by treatment of the surface of the soil in glasshouses with fungicides before planting out. There are indications that some of these treatments are of value.

Formaldehyde vapour proved an effective means of destroying air-borne spores in glasshouses and the surface of soil treated with formaldehyde (1:49) did not become re-infected until seven days after treatment. A proprietary tar acid sterilizing fluid used under similar conditions did not destroy free spores and was less effective than formaldehyde in controlling soil infection by spores. The strain of *Didymella* which attacks the fruit only and not the stems of outdoor tomatoes did not cause stem rot under glass.

Evidence has been obtained which indicates that fruiting tomato plants may, under certain conditions, show marked resistance to invasion by mosaic viruses. The prohibition of smoking on nurseries is often found to be impracticable and it is suggested that where plants are well-nourished and grown under favourable conditions, the leaves may have the capacity to localise virus infection at low concentrations such as would be introduced into plants by contamination through the

hands of workers using infective smoking tobacco. Experiments have been started with young plants to investigate the most favourable nutrient balance in the soil compatible with satisfactory growth and high resistance to mosaic infection. The tree tomato (Cyphomandra) has been found to be susceptible to potato mosaic virus (Potato virus X). The reaction of two species of thornapple (Datura) to the tobacco mosaic virus has been studied.

As a result of recent researches into the distribution of plants infested with Red Spider Mite in tomato houses early in the growing season, an experiment has been carried out upon a commercial nursery. This involved the spraying with petroleum emulsion of six rows of plants only, in the area beneath the ridge of a glasshouse. Owing to an abnormally late appearance of mites upon the plants, the spray was applied at the end of May. In July it proved unnecessary to apply further measures for control in the treated house, whereas in adjacent houses of the block a severe infestation had developed, in spite of the application of sprays at the end of June, to all the plants in them. A considerable amount of oedema, however, developed upon the plants which were given two applications of spray in May.

The effects upon the mite of giving a second application of petroleum emulsion within a few days of the first, and of giving single applications with emulsions to which calcium chloride has been added have been observed upon a larger scale than previously undertaken. Though no very accurate method of evaluation could be devised, the results indicate that the two methods produce much the same effect, and that the check to infestation is very much greater than that obtained from a single spraying without the addition of calcium chloride.

Some preliminary experiments in host-transference have been carried out with species of Green fly belonging to the genus Macrosiphum.

At certain stages of growth, the sap of tomato plants appears to contain some substance which is toxic to certain species of Aphids.

Some attempt has been made to study the amount of variability in morphological characteristics which have been employed by authorities to separate species of Macrosiphum from one another.

Males of the Onion Thrips (*T. tabaci* Lind.) have been collected from leeks grown in a neighbouring garden. The male of this insect is of great rarity, and in Great Britain (and possibly Europe) has previously only been recorded once from the north of Scotland.

Application of sodium ethyl xanthate in solution to the soil of a plot infected with Root-knot eelworm appeared to have reduced slightly the number of galls produced upon the roots of tomato plants as compared with an untreated control. The root development, and subsequent growth of the plants in the treated plot were severely checked as a result of the application.

Large scale trials with DDT have proved the value of this substance for the control of Tomato Moth Caterpillars. The advantages of DDT dusts during the early part of the season have been demonstrated. Trials have also been made with DDT for the control of other insect pests of glasshouse plants.

Periodic determinations of the chloride concentration in plots which have continued to receive potash as chloride and muriate respectively have been carried out as in previous years. As already reported peak values for chloride are shown in the early part of the season following the dressings of muriate but these do not persist and we now have ample confirmation for the conclusion that the tomato plant will tolerate relatively high chloride concentrations in the soil providing they do not persist. Where the water supply has a low chloride content the ordinary watering keeps down the concentration of soil chlorides below the

danger level. It is still necessary, however, to point out that where the soil and water supply contain chlorides only the sulphate should be used to supply potash.

Experiments on the effects of sulphur and of sulphuric acid on the reaction of tomato soil have again been made. This year a dressing of sulphur at the rate of 2 tons per acre was given to one plot. This caused a drop of approximately 0.8 in the pH value within a few weeks of the application. There was, however, a gradual recovery in the value later in the season. The nett result over the full year was that an original pH value of 7.5 fell to 7.14. Over the same period the carbonate content of the top six inches fell from 2.4 per cent. to 1.5 per cent. The addition of sulphur at the rate of half-a-ton per acre had little permanent effect on either the pH value or on the carbonate content. The addition of sulphuric acid at a rate equivalent to half-a-ton per acre of sulphur reduced the pH over the year from 7.4 to 7.0 and the carbonate from 2.8 to 1.5. Where elemental sulphur was added there was no apparent effect on the growth but the addition of sulphuric acid depressed the rate of growth for some three or four weeks after planting. In all cases the effects on the total crop produced were slight.

Experiments on deficiences in tomato and winter lettuce have been continued. Trials at various nurseries under strictly commercial conditions have shown that magnesium deficiency in tomatoes is effectively corrected by spraying periodically with a 2% by weight solution of Epsom Salts with a suitable wetter.

The possibility that there might be some fairly constant relation between the potash and phosphoric acid extracted from soil by 1 per cent. citric acid and 0.5N acetic acid respectively has been further examined. From the examination of a number of tomato soils from various localities it is concluded that there is no hard and fast relationship. It would appear that none

of the methods examined for the "availability" of potash and phosphoric acid in tomato soils is to be recommended in preference to the others.

The effect of some of the plant hormones on the setting of tomato fruit has been studied and as a result it has been found that betanaphthoxyacetic acid at a concentration of between 35 and 50 parts per million in water with a suitable wetter is satisfactory and a concentration of 40 p.p.m. is recommended. Promising results have also been obtained with alpha 2 : 4 dichlorophenoxypropionic acid.

Obituary.

IT is with profound regret that we record the death on November 8th, 1945, of our President, Mr. Jacob Nielsen in his 82nd year. Mr. Nielsen came to this country from Denmark some fifty years ago, and was at first in partnership with Mr. H. O. Larsen at Riley Road Nurseries. Later he built a nursery at Waltham Cross and finally at Smallford, near St. Albans.

We remember our late Presidents, Mr. Larsen, Mr. Shoults and Mr. Nielsen as the "three musketeers." They were close friends, and were always to be found doing good work together.

They were chiefly responsible for the development of the Research Station and we are grateful for their generosity on many occasions, when we found ourselves in financial difficulties. They guaranteed large sums of money so that our extension projects could be put in hand and few people know just what the Research Station owes to them. It is sad to think that we shall see them no more on earth.

Our debt of gratitude to Mr. Nielsen is increased by his considerable interest in our work and the manner in which he kept us informed of developments in Denmark. He loved his native land and never tired of recounting his visits to growers there. He was always willing to help us by means of experiments on his own nurseries and his critical mind was a valuable asset in estimating results. He spent many hours going through our experimental houses and took special delight in discovering a plant which was doing badly or had contracted some disease which should not appear in a Research Station's crop. For all this we honour him, but it was his genial, boyish nature and the "twinkle in his eye" which gained our affection.

One of our happiest recollections is of a trip across the Zuider Zee in a fishing boat, with Mr. Larsen, Mr. Shoults, Mr. Nielsen and some of their cronies.

It was a joy to see how such prominent growers and business men could forget the cares of the day, and relax so happily and completely as did the party on that never to be forgotten occasion. We mourn the passing of great men, but their example is for ever with us.

DIRECTOR'S REPORT

of the

Experimental Results of 1945.

Tomatoes.

The practice of grading the tomato fruits from the experimental plots, adopted in 1921, was continued :—

A.—" Pinks " number 5 to 7 and " Pink and White " 8 to 10 to the pound. These are the best quality of fruit in size, shape and colour ; " Pinks " being slightly larger than " Pink and " Whites."

B.—" Whites." These fruits are of good colour but smaller than " Pink and White."

C.—" Blues." This grade consists of fruits of good colour but larger and more irregular in shape than Grade A.

D.—" Roughs." Small mis-shapen fruits about the size of cherries.

E.—Blotchy fruits which ripen irregularly.

F.—Fruits showing Blossom End Rot.

G.—Fruits showing the lesions of Streak Disease.

H.—Fruits showing " Green Back."

1. Houses 7-9. Sulphate of potash versus muriate of potash

The experiments in these three houses commenced in 1940 have been continued. Two plots in each house have received the ordinary base and top dressing treatments, while in the two remaining plots sulphate of potash has been replaced by the muriate during the six years of the experiment. The normal treatment is as follows :—

1.—Applied before planting

Hoof and horn	10 cwts.	per acre
Bone meal	10 ,,	
Sulphate of potash	10 ,,	

2.—Top Dressing

(*a*) Sulphate of potash 5 cwts. per acre.

(*b*) A top dressing mixture containing 10% potash as sulphate of potash totalling 20 to 30 cwts. per acre as required.

The results set out in Table 1 confirm those obtained during the past four years. The chemical aspect of the problem is discussed in the chemical section of this report.

Table 1.

Varieties :—Houses 7 and 8 Potentate. House 9 E.S. 1.

House	*Plot*	*Treatment*	*Crop weight in lbs. per plant*						*Total tons per acre*		*% blotchy fruit*
			June	*July*	*Aug.*	*Sept.*	*Oct.*	*Total*			
7	1	Sulphate of potash	1.32	2.84	2.41	1.59	1.01	9.17	69.69		2.18
	3	,, ,, ...	1.04	2.74	2.10	1.33	0.99	8.20	62.32		1.46
8	2	,, ,, ...	1.21	2.99	2.40	1.33	1.07	9.00	68.41	61.52	2.44
	4	,, ,, ...	1.14	2.68	1.87	1.37	1.05	8.11	61.63		3.33
9	3	,, ,, ...	0.62	2.19	2.46	1.30	0.56	7.13	54.18		2.39
	4	,, ,, ...	0.78	2.25	2.24	1.16	0.53	6.96	52.89		2.73
7	2	Muriate of potash	1.13	3.03	2.20	1.35	0.97	8.68	65.97		2.55
	4	,, ,, ...	1.25	2.86	1.76	1.08	1.01	7.96	60.49		2.38
8	1	,, ,, ...	1.16	2.84	2.09	1.36	1.05	8.49	64.53	61.41	3.89
	3	,, ,, ...	1.27	2.61	1.86	1.25	1.09	8.08	61.41		2.72
9	1	,, ,, ...	0.86	2.31	2.23	1.45	0.56	7.41	62.34		0.14
	2	,, ,, ...	0.75	2.15	2.38	1.22	0.57	7.07	53.73		0.28

2. House 3

Complete artificials versus sulphate of potash only as a base treatment after steam sterilisation.

House 3 steam sterilised during the winter months, was divided into four plots. Two plots received sulphate of potash only at the rate of 10 cwts. per acre, while the remainder received 30 cwts. per acre of a complete base mixture. The variety grown was Potentate and the results are given in Table 2.

Table 2

House 3. Potentate.

Plot	*Base Treatment*	*Crop Weight*			*% blotchy fruit*
		Total lbs. per plant	*Total tons per acre*	*Average tons per acre*	
1	Sulphate of potash only	6.99	53.12	51.90	4.58
3	,, ,,	6.67	50.69		3.60
2	Complete artificials	7.16	54.41	51.90	4.05
4	,, ,,	6.50	49.40		3.23

The results confirm those obtained previously on this land, namely that a dressing of sulphate of potash only, is a sufficient base dressing for tomatoes after steam sterilisation of the soil.

3. House 5

The effect of applying sulphur or sulphuric acid to the soil before planting

This experiment was started in 1943 to see if any improvement in crop weight or quality could be obtained by lowering the pH of the soil.

The results are set out in Table 3 and the chemical aspect is discussed in the Chemical Section of this report.

4. House 4. Manurial Trials. Variety—Harnett's Ideal.

The manurial trials started many years ago have been continued. The results are given in Table 4.

Table 3

House 5. Potentate.

Plot	*Treatment*	*Crop yield*			% *blotchy fruit*
		Total lbs. per plant	*Total tons per acre*		
1	Control	6.75	51.29		4.7
2	,, ...	7.15	54.29		2.8
3	,, ...	7.17	54.46	52.71	2.0
7	,, ...	6.74	51.14		3.3
8	,, ...	6.89	52.38		3.9
6	Sulphur 4 ozs. per sq. yd. ...	7.13	54.21		2.3
4	Sulphur 16 ozs. per sq. yd. ...	7.01	53.95		2.2
5	Sulphuric acid equivalent to dressing of sulphur in plot 6	6.93	52.68		2.7

Table 4

House 4. Harnett's Ideal.

Plot	*Treatment*	*Crop weight*		% *blotchy fruit*
		Total lbs. per plant	*Total tons per acre*	
1	No nitrogen	2.73	21.82	9.7
2	Unmanured	3.17	24.06	27.2
10	No potash	3.59	27.29	36.2
9	No phosphates	5.20	39.51	8.6
3	Complete artificials	4.73	36.03	6.3
8	Complete artificials with horse manure	5.84	44.38	3.8
4	Standard Control	6.72	51.00	3.7
7	Standard Control	6.54	49.79	2.7
6	As plots 4 and 7 but without lime (3rd year)	6.05	45.99	2.5

The results show, as they have done ever since the experiments commenced, that the omission of potash leads to a very high percentage of blotchy ripening. It is clear also, from the figures that potash deficiency is not the only factor influencing imperfect colouring, although it is responsible to a very high degree.

Lime has been withheld from Plot 6 during the past three years without any appreciable result, but the crop weight this year is lower than it was previously when compared with that of the controls. Future results will be necessary to show the general trend of the crop on this plot.

5. Variety Trials

(a) Leaf Mould Resisting varieties

Four resistant varieties were compared in House 1, namely Vetomold, V121, Leaf Mould Resister No. 1 and Jersey Leaf Mould Resister. The results are given in Table 5.

Table 5

Plot	*Variety*	*Crop weight*		*% blotchy fruit*	*Degree of resistance*
		Total lbs. per plant	*Total tons per acre*		
1	V121	5.29	44.92	1.01	Resistant
2	L.M.R. No. 1 ...	6.94	52.74	1.82	Very resistant
3	Jersey L.M.R. ...	5.19	39.44	—	,, ,,
4	Vetomold	5.16	39.21	0.39	Resistant

Leaf Mould Resister No. 1 raised at the Experimental Station gave the highest yield and proved to be the most resistant variety. Jersey Leaf Mould Resister is obviously a strain of the former.

(b) Other varieties

The results of the trials with other varieties are given in Table 6.

Bountiful and Ragworth Beauty were similar in type except for the pronounced and somewhat square shoulders, which appeared on many Bountiful fruits.

Varieties. **Table 6.**

	Variety	*lbs. per plant*	*Tons per acre*	*Remarks*
1.	Ragworth Beauty	8.45	63.62	A consistently good cropper. Ailsa Craig type, moderate growth. Good cropping qualities in the tops.
2.	Finney's Sport	7.97	60.57	Moderate in growth : fruit somewhat like Carrick : many irregular in shape.
3.	Raes Renown	7.90	60.04	All three of Ailsa Craig type. Number 4 is good in tops. Number 3 consistently good. Number 5 strong growth.
4.	Downe's Seedling	7.87	59.81	
5.	BRI	7.87	59.81	
6.	Kondail : Searby	7.82	59.43	Not a true Kondine, fruits are more spherical—an excellent variety for large pot culture. Foliage and shoots somewhat gross.
7.	Kondine	7.81	59.36	Sutton's Kondine.
8.	E.S.4	7.75	58.90	Fruit good throughout : growth rather luxuriant.
9.	Bountiful	7.73	58.75	Cropped well on bottom : growth similar to Ailsa Craig : many fruit were somewhat square with pronounced shoulders.
10.	Daffern's Seedling	7.19	54.65	A good Ailsa Craig type, not quite as large : proved excellent in pots : better as a second crop later.
11.	Robinson's Graday	7.13	54.19	Another Ailsa Craig type : fruits medium in size, but good even shape.
12.	Pomfrett Castle	7.12	54.11	Proved far better when grown in low houses : fruit colour of Stonor's varieties : early, not a strong growth in tops.
13.	Sarnian Beauty	7.11	54.04	Another light coloured fruiting type. Fruit rather small, irregular in shape.
14.	Comet	6.88	52.29	Coarse heavy foliage : large fruit but of excellent flavour.
15.	Potentate x Sutton's Best of All	6.85	52.06	Potentate type of fruit : trusses larger and with more fruit than Comet. Very weak in top growth.
16.	King of Tomatoes	6.83	51.91	A small fruited variety, barely medium in size : colour early, as in Stoner's varieties : growth generally, and top medium.
17.	E.L.S.A.	6.00	45.60	Excessive growth : fruit angular. Rather poor setter : evidently at best in pots or a poorer type of soil.
18.	Kondail : Chenery	5.75	43.70	More suited for pot culture : growth excessive : fruit medium to large, not very good in shape.

Tomatoes in Cucumber Houses.

Table 7.

House	*Plot*	*Treatment*	*Crop yield in tons per acre*					*Total*	
			May	*June*	*July*	*August*	*September*		
D.	1	Roof crop with two rows in front ...	2.32	18.50	10.20	6.70	6.65	44.37	
D.	2	Ditto	2.59	15.74	10.20	7.16	5.00	40.69	
F.	1	Ditto	2.20	19.63	10.98	5.10	2.65	40.56	
F.	2	Ditto	2.52	20.44	10.10	4.91	3.10	42.07	
E.	1a	Roof crop—1 row in grond ...	0.75	7.93	8.36	8.71	3.50	29.25	39.51
E.	1b	Plants in size 32 pots in front ...	3.67	6.59	—	—	—	10.26	
E.	2a	As E.1a	0.81	8.26	8.49	8.35	4.27	30.18	41.14
E.	2b	As E.1b	3.59	7.37	—	—	—	10.96	
G.	1a	As E.1a	1.10	8.68	8.72	8.32	6.12	32.94	43.79
G.	1b	As E.1b	5.79	5.06	—	—	—	10.85	
G.	2a	As E.1a	1.32	9.26	8.02	8.54	6.29	33.43	42.99
G.	2b	As E.1b	6.24	3.32	—	—	—	9.56	

Kondine, (Searby and Chenery) are varieties best suited for large pot culture. E.S.4., B.R.1., Dafferns seedling and Downes seedling produced the best fruit, in size and quality.

Pomfrett Castle was rather disappointing in a large house, but grown in the cucumber houses during 1944 it produced a very fine root crop. The fruit of Sarnian Beauty was far small.

The growth of E.L.S.A. was excessively wild : pot culture with root restriction is evidently necessary.

Robinson's Graday although not one of the heaviest croppers can be recommended for quality and shape.

6. Tomatoes in cucumber houses

Tomatoes Potentate and Exhibition were again grown by the roof crop method in the cucumber houses, but owing to the fact that the soil had not been sterilised for three years the crop was lower than usual. In houses D. and F. the plants were planted and trained according to the usual method. In houses E. and G. the two front rows of plants on both sides of the path were replaced by twice the number of plants in size 32 pots. These plants were stopped at the second truss to allow the lower parts of the back rows (the roof rows) to receive more light than is possible by the usual method of planting. These plants were removed after cropping.

This year's results did not show any increase in crop yield through planting the front rows in pots, but there was a pronounced earliness in picking from the pot plants. Thus the average weight of crop in May was 2.41 tons per acre in the normal houses and 5.67 tons per acre where pots were used. So although no advantage can be claimed from planting in size 32 pots, it has been shown once more that early crops can be produced in this way. The results are given in Table 7.

2. PLANT DISEASES.

1. General.

P. H. WILLIAMS.

The number of specimens received during the year has shown a considerable reduction, although still above the pre-war level. A total of 425 were examined of which 73% were tomatoes. Several interesting new records were made during the year.

A consignment of tomato fruit developed a severe spotting and rot during transit to market, about 50% being affected. *Penicillium* sp. was found on the spots and on dead calyces. It was discovered that the plants from which the fruit had been picked were suffering from severe Oedema involving stems, truss stalks and sepals following the application of an oil emulsion spray. *Penicillium* was growing on the dead sepals and it is thought that under the moist conditions in the packages, the fungus spread to the fruit.

Two cases of infection of outdoor tomatoes with Early Blight (*Alternaria solani*) have been recorded, one from Essex and the other from the Isle of Wight. This disease causes spotting and decay of leaves and fruit in addition to stem rot. In the United States of America it also causes damping off and foot rot of seedlings. In this country it was recorded by Glasscock and Ware in 1944 and since then a number of cases have been reported.

The disease appears to be controlled in the field by spraying with copper compounds so that routine spraying against Late Blight (*Phytophthora infestans*) with Bouisol and oil emulsion should keep it in check. Reports that the seedling disease can be controlled by seed sterilization suggest that the fungus may be seed-borne. The occurrence of this disease on outdoor tomatoes provides another reason against taking seed from crops in the open.

A species of *Oedocephalum* has been found growing on the casing soil of a mushroom bed. Another species of the same genus was found on the surface of the soil in a tomato seed box. In both cases the soil particles were matted together but no definite injury was caused to the crop. Fungi of this group are reported to grow on decaying leaves and other vegetable remains and it was probably on such material that the specimens seen were introduced into the soil.

Last October, *Pythium* sp. was found destroying sporelings of *Pteris major*.

2. Verticillium Wilt.

P. H. WILLIAMS.

The investigation of *Verticillium* Wilt of the tomato has been continued and preliminary experiments on the same disease of cucumbers have been carried out.

A. Tomatoes

(a) The effect of temperature on the disease

In the 29th Annual Report for 1943 it was shown that *Verticillium dahliae* would grow at slightly higher temperatures than *V. albo-atrum*. It was suggested that wilt caused by *V. dahliae* might not be controlled by raising the temperature as can be done with wilt caused by *V. albo-atrum*. An experiment designed to investigate this point was carried out this year.

Tomato plants, variety Potentate, were grown in 9 inch pots and inoculated by placing a piece of a Petri dish culture under the ball of roots when potting. Eight plants were inoculated with each fungus and there were eight controls. Four plants from each series were then subjected to higher temperatures than the remainder. In the absence of pipe heat, the higher temperature was obtained by keeping the chamber in which the plants were growing closed. This resulted in higher atmospheric humidities in this chamber and it is impossible to distinguish between the effects of temperature and humidity in this experiment. Nevertheless, the conditions in the closed chamber approximated to those obtaining in houses where the usual control methods for *Verticillium* Wilt are being employed. The other plants were kept in a chamber which was ventilated normally. The experiment was started on May 14th and ended on August 13th. The temperature and humidity conditions for this period are shown below.

Temperature °F		*High*	*Normal*
Average	...	72.0	67.5
Absolute Maximum	...	106.0	98.0
Average Maximum	...	86.4	79.2
Absolute Minimum	...	53.0	52.0
Average Minimum	...	63.0	60.5
Humidity %			
Average	...	85.4	71.6
Absolute Maximum	...	96.0	98.0
Average Maximum	...	91.2	86.3
Absolute Minimum	...	26.0	28.0
Average Minimum	...	70.1	48.9

The plants grew well at first but later some difficulty was experienced in keeping the soil sufficiently wet. Leaching of nutrients by frequent waterings made it difficult to maintain the balance of

the plants so that some yellowing of the leaves appeared which made counts of dead and yellow leaves unsatisfactory. Nevertheless the experiment has given useful indications of the effect of these environmental conditions on the two diseases.

The first sign of infection was a bending down of the petioles of the lower leaves (epinasty). It first appeared in the "normal" chamber after 14 days and by the 24th day all the inoculated plants showed it. This symptom is not characteristic of *Verticillium* Wilt only. It has been reported as occurring in the wilts caused by *Fusarium bulbiginum* var. *lycopersici* (*Fusarium* Wilt) and *Xanthomonas solanacearum* (Bacterial Wilt). It may also be seen in plants infected by *Phytophthora* spp.

The plants inoculated with *Verticillium albo-atrum* and kept under normal conditions began to wilt slightly after 22 days. The wilt became more severe in the next few days so that the tops flagged and growth ceased. By about the 31st day, however, the plants began to show signs of recovering and after a further 6 to 10 days growth was resumed. The new growth was thin and weak but appeared outwardly to be quite healthy. Similar recovery after wilting under normal conditions has often been observed on the Station nursery.

Plants inoculated with *V. albo-atrum* in the closed chamber did not wilt at all.

Counts of dead and yellow leaves at the end of five weeks showed that 52.1% of the total leaves were affected in the normal chamber and only 1.4% in the closed. The controls showed 6.0% and 4.8% respectively.

Serial isolations at 1 foot intervals were made from each plant at the end of the experiment. *V. albo-atrum* was isolated from only 3 of the 4 plants in the closed chamber. It was isolated at cotyledon level in two plants and up to 1 foot in one plant. In the normal chamber, the fungus had penetrated to 4 feet in one plant and to 2 feet, 1 foot and 1 foot 6 inches (top of plant) in the others.

It is apparent from these results that the development of wilt due to *V. albo-atrum* was checked by the warm moist conditions in the closed chamber.

Of the plants inoculated with *V. dahliae* under normal conditions, one wilted after 77 days and died two days later. The remainder did not wilt but developed the characteristic yellowing of the leaves. In the closed chamber, two plants wilted slightly after 4 weeks but soon recovered.

Counts of dead and yellow leaves after 5 weeks gave 25.0% of the total number of leaves in the closed chamber and 23.75% in the normal.

Serial isolations showed that the fungus had penetrated to cotyledon level in 2 plants, to 2 feet in the 3rd plant and to 1 foot in the fourth in the closed chamber, and to 4 feet, 2 feet and 1 foot respectively in the 3 plants in the normal chamber.

These results suggested that *V. dahliae* is checked to some extent by the higher temperature and humidity but not so decisively as is *V. albo-atrum.*

(b) The effect of soil moisture

Tomatoes, variety Potentate, infected with *Verticillium albo-atrum* and *V. dahliae* in the usual manner were grown in 9 inch pots. They were divided into 4 series.

(1) Standing in earthenware saucers filled with water and watered each day.

(2) Normal watering.

(3) Watering reduced after wilting.

(4) Watered only when the plants were flagging.

Two plants inoculated with each fungus and two controls were assigned to each series. The experiment was started on May 14th. In practice the distinction between the last 3 series could only be maintained for the first five or six weeks. After this the requirements of the plants necessitated watering the controls at least once each day. The wilted plants were only watered when necessary.

The plants inoculated with *V. albo-atrum* in series 2 and 3 began to wilt after 3 weeks and those in series 4 four days afterwards. The wilt became severe with flagging of the tops and cessation of growth after another three to four days. The plants in series 1 remained free from wilt for a week longer than those in series 2 but the disease then progressed very rapidly. The plants were wilting slightly at 10 a.m. on June 13th and collapsed completely by the afternoon. Subsequently they recovered during the night but two days later again flagged badly in the sun. In all the series, the plants slowly recovered and by the end of July all were growing away.

Counts of dead and yellow leaves made after 5 weeks gave the following results (Table 1).

Table 1.

Percentage of Dead and Yellow Leaves.

	1	2	3	4
V. albo-atrum	50.0	70.6	81.3	61.3
Control	2.3	7.7	5.1	8.1

It thus appears that high soil moisture may slightly delay the onset of wilt caused by *V. albo-atrum* but the final intensity of the disease is not affected.

The plants inoculated with *V. dahliae* showed no striking differences due to soil moisture. One plant in series 1 died at the end of July. The others showed the usual yellowing of the leaves with poor, thin growth of the top.

Counts of affected leaves after 5 weeks are shown in Table 2.

Table 2.
Percentage of Dead and Yellow Leaves.

	1	2	3	4
V. dahliae	21.9	23.7	39.5	25.0
Control	2.3	7.7	5.1	8.1

It will be noted that with both *V. albo-atrum* and *V. dahliae* the percentage of affected leaves in series 3 was considerably higher than in series 2. No explanation of this is at present possible. It is hoped to repeat this experiment in the coming season.

B. Cucumbers

Two specimens of cucumber wilt were received during the year and in each case the fungus isolated was *V. albo-atrum*.

Inoculation experiments

Cucumber seeds, variety Butcher's Disease Resister, were sown in size 60 pots half filled with sterilised compost. After germination, the pots were filled up with compost and when the plants were large enough they were potted on into 9 inch pots. Six plants were inoculated with *V. albo-atrum* and six with *V. dahliae* by putting a piece of culture under the ball of roots and there were six controls. The experiment was started on June 9th and the plants were kept in the closed chamber mentioned above. In a second experiment started on September 22nd the number of plants was doubled and half were placed in the closed chamber and half in the "normal." The results obtained with the two fungi will be considered separately.

(a) *V. albo-atrum*

In the first experiment, very slight wilting involving only one leaf was observed on June 19th (10 days). Subsequently the wilt developed, the leaves showing pale yellow green areas which lost their turgidity and later dried out. Isolations made on July 25th confirmed the presence of *V. albo-atrum* in the tissues. The controls all remained healthy. The temperature and humidity conditions during the experiment were as follows :—

	Temperature °F	*Humidity* %
Average	72.9	86.7
Absolute maximum ...	106.0	96.0
Average	85.9	91.7
Absolute minimum ...	58.0	45.0
Average	64.7	79.4

It will be seen that cucumber plants wilted under conditions which checked the disease in tomatoes.

In the second experiment the fungus produced much more severe effects. In addition to the typical yellowing and drying out of the leaves, the tips of the infected plants became dark green and hard and in some cases died. The plants were also very stunted. In the closed chamber the height of the infected plants varied from 3 to 14 inches, average 9.6, the controls 33 to 41 inches, average 36. In the " normal " chamber, corresponding figures were 6.0 to 12.5 inches, average 8.1 inches and 26 to 34 inches, average 30.3 inches.

Serial isolations showed that in every case the fungus had penetrated to the top of the plant.

These experiments suggest that the wilt caused by *V. albo-atrum* is favoured by low temperatures and that temperatures sufficient to control the disease would have to be higher than with the tomato.

(b) *V. dahliae*

In the absence of cultures of *V. dahliae* isolated from cucumber, strains isolated from tomato had to be used.

In the first experiment, strain 60 isolated in 1944 was employed. There was no infection.

In the second experiment, a newly isolated strain, number 65, was used. After about 3 weeks it was noted that the bottom leaves of some of the plants were flagging and turning yellow. A week later, it was apparent that these plants were somewhat stunted compared with the controls. The tops of the plants remained bright green in contrast to the dark green of those infected with *V. albo-atrum*. The plants were finally cut out on November 7th, the height of each plant and the number of dead and yellow leaves recorded and serial isolations made at 1 foot intervals. One plant in the " normal " chamber had apparently become infected with *V. albo-atrum* judging by its external appearance and this was confirmed by the isolations. The results are shown in Table 3.

It will be seen that *V. dahliae* does not cause the death of the leaves to the same extent as does *V. albo-atrum*. Where the fungus had progressed beyond the cotyledons the plants were shorter than the controls but there was no other outward sign of infection. It seems possible therefore that plants infected with *V. dahliae* might escape notice on a nursery.

So far it is not clear whether the successful inoculation of cucumbers with *V. dahliae* in the second experiment was due to the greater virulence of the recently isolated culture or to the low temperatures. It is hoped to clear up this point during the coming season.

Table III. Results of inoculating cucumbers with *V. dahliae*

	"Closed Chamber"			*"Normal Chamber"*		
	Height ins.	*No. of affected leaves*	*Infection up to ins.*	*Height ins.*	*No. of affected leaves*	*Infection up to ins.*
Control (Av)	54.1	3.1	None	46.3	2.5	None
Inoculated	46.0	1	36.0	22.0	4	21.0
,,	54.0	2	Cotyledons	37.0	5	36.0
,,	62.0	3	None	49.0	2	None
,,	59.0	4	,,	29.0	2	24.0
,,	57.0	4	Cotyledons	45.0	3	None
,,	36.0	2	12.0	45.0	14	x

x Infected with *V. albo-atrum*.

Cross inoculation experiment

Freshly isolated cultures of *V. albo-atrum* from tomato and cucumber and a strain of *V. dahliae* isolated from tomato in 1944 (strain 60) were grown in Dox solution. After 14 days' growth on this medium the fungi were used to inoculate tomato and cucumber seedlings by dipping their roots in the cultures before potting into 60 pots.

All the plants inoculated with *V. albo-atrum* developed typical symptoms and the fungus was reisolated from them, proving that *V. albo-atrum* from tomato can infect cucumber and vice versa.

The tomatoes inoculated with *V. dahliae* became diseased and the fungus was reisolated. The cucumbers remained healthy. However, it has been shown above that *V. dahliae* from tomato is capable of infecting cucumbers under certain conditions. In the absence of cultures from natural infections of *V. dahliae* on cucumbers it has not yet been possible to prove that *V. dahliae* from cucumber will infect tomato.

3 (a). Stem Rot of Tomato caused by *Didymella lycopersici*.

ENID SHEARD†.

Relation of *D. lycopersici* on outdoor tomatoes to the disease under glass

Hickman, working on outdoor tomatoes at Evesham has shown that the strain of *Didymella* which attacks only fruits, will not

† The work on aerial spore transmission and fumigation with formaldehyde was carried out in collaboration with Mr. O. B. Orchard.

attack tomato stems. An inoculation experiment was carried out to determine if the strain of *Didymella* which attacks outdoor fruit only would infect stems under glass. Spore suspensions in water were made from an infected fruit from an outdoor crop in which no stems were affected and from a fruit which had become infected in contact with the soil in a glasshouse containing infected plants. The suspensions were sprayed on to the stem bases of tomato plants a number of which had been wounded before spraying by scraping off the epidermis. Extensive stem rot developed in the wounded and unwounded stems inoculated with the stem-rotting strain of the fungus. None of the unwounded stems rotted after inoculation with spores from the outdoor fruit and a very slight infection occurred on one of the wounded plants. The infection was restricted to the wounded area and did not spread, whereas the stem rotting strain ultimately killed the plants. Isolations were made from two other fruits from outdoor crops where no stem rot had occurred and in pure culture these strains remained distinct from isolates made from infected stems of glasshouse plants. It is concluded that the strain of *D. lycopersici* which infects fruit only on outdoor plants is not pathogenic to the stems of glasshouse plants. It is known that the strain which infects outdoor stems will also infect the stems of glasshouse plants.

Aerial spore transmission

A feature of *Didymella* attacks under glass is the occurrence late in the season of secondary lesions high up on the stems of the plants. It has been shown previously that *Didymella* spores can be carried from plant to plant by splashing during watering operations and on the knives of workers. These methods, however, did not appear to account for many of the secondary lesions found five to six feet above the ground when all the primary lesions had been at or slightly above soil level. Furthermore an attack was investigated where there had been no primary lesions at the bases of the stems and all lesions were over three feet above the soil. This suggested the spores might be air-borne and sterilised plates containing nutrient agar were exposed in a house of infected plants in an attempt to trap *Didymella* spores.

Petri dishes containing Dox agar were exposed at different heights above the ground and for varying lengths of time in the house containing infected plants. In some the agar surface faced upwards and in others, downwards. Plates also were carried at different heights along the path of the house with the agar surface held vertically. After exposure the plates were kept at room temperature in the light. After a week the plates were examined and any fungus resembling *D. lycopersici* was transferred to Dox agar slopes and later inoculated into tomato stems. Any lesions which resulted were compared with those produced by a pure culture of *D. lycopersici*.

D. lycopersici grew on the plates exposed for 1, 5 and 15 minutes on the ground and 3 ft. and 7 ft. above the ground. The majority of spores of any fungus were trapped on the plates exposed with the agar surface facing upwards. Plates exposed for 5 and 15 minutes became covered with fungus and bacterial colonies after incubation and it was difficult to distinguish the *Didymella* colonies. In subsequent experiments the plates were exposed with the agar surface facing upwards for 1 minute on the ground and 7 ft. above the ground, the latter being a convenient height as the plates could be placed on the wooden cross-ties running across the houses.

In July, plates were exposed on the same nursery in empty houses which had been damaged by enemy action the previous year and were then being repaired. Plates also were exposed outside the houses. *Didymella* spores were trapped in both places, showing that spores are carried in air currents outside the glasshouses as well as in houses in which infected plants are growing. The plants grown in the damaged houses after they had been repaired became infected with *Didymella*.

Plates were exposed on the same nursery at the beginning of November and December when sterilising was in progress. At both times *Didymella* spores were trapped inside and outside the houses. Some of the houses in which spores were trapped had been sprayed with formaldehyde. Tests made 24 hours after treatment showed that any free spores in these houses had been killed at that time but when the plates were exposed, tomato roots with about two feet of stem bearing pycnidia containing viable spores, remained in the houses not yet treated and it is likely these were the source of the trapped spores.

In October, plates were exposed on a second nursery on which an outbreak of stem rot had occurred two months before. In this case, although a careful examination was made, no lesions were seen at soil level and all lesions were 3 ft. to 4 ft. above the ground and it seemed likely that infection had been air-borne. No *Didymella* spores were trapped inside the infected house but *Didymella* grew on one plate exposed outside the house. Three weeks later more plates were exposed after the plants had been pulled out and taken away. *Didymella* grew on one plate exposed 3 ft. above the ground in the house and on 2 plates exposed outside the house.

The results of these experiments show that *Didymella* spores can be air-borne. This may account for some of the secondary lesions which occur high up the stems on glasshouse plants and for outbreaks where all the lesions are of the secondary type. The trapping of spores outside during the winter months when the plants had been removed from the houses indicates a means by which the soil may become recontaminated after sterilisation and it is interesting to note at the beginning of 1946, when *Didymella* spores had con-

stantly been trapped out-of-doors on the nursery where the first tests were made, a pile of tomato haulms was found in the vicinity, bearing pycnidia which contained viable spores. Previous experiments showed the fungus remained viable on tomato stems for 12 months and it is most important to burn all infected tomato haulms at the end of the season or they will provide a source of infection by means of air-borne spores for the next year's crop.

Toxicity of fungicides to *Didymella* spores

In commercial practice *Didymella* frequently attacks plants which are growing in steamed soil or soil treated with formaldehyde or proprietary sterilising fluids. A number of chemicals have been tested in an attempt to find a fungicide which can be used immediately before planting and also after the plants are in the soil, which will prevent reinfection of the soil by air-borne spores and destroy any fungus which has not been killed by the earlier treatment or has entered the soil between that time and planting.

Spore suspensions were prepared by soaking infected stems in distilled water and filtering the suspension through two layers of cheesecloth to remove pycnidia and stem tissue. The suspension and, in later experiments, spores centrifuged from the suspension and allowed to drain, were treated with the solutions to be tested. Two ml. of solution were used for each test. The spores were (*a*) left in the solution (*b*) treated for 1 hour, centrifuged out and drained and (*c*) treated for 1 hour, centrifuged out and washed in two 10 ml. lots of distilled water. The treated spores were placed in drops of liquid on glass slides resting in petri dishes lined with damp filter paper, and examined for germination. Spores from infected stems were used because of the difficulty of producing spores in pure culture. The germinating *Didymella* spores were easily distinguished from any contaminations by the characteristic mycelium produced and the ability to form pycnidia after a week in tomato juice. It was found that the majority of viable spores germinated after 24 hours and germination was complete after 48 hours.

In the preliminary experiments spores were germinated in tap water and in diluted tomato juice. Germination was quicker and a greater number of spores germinated in diluted tomato juice prepared from stems and fruit than in tap water and in subsequent experiments tomato juice only was used. It is interesting to note that the toxicity of copper salts to *Didymella* spores is reduced in the presence of tomato juice. Spores treated with a 5% aqueous solution of copper sulphate for 1 hour did not germinate when transferred to tap water, whereas a number of the spores did germinate in tomato juice. After six days tomato juice was added to the tap water preparations and a number of the spores germinated. The ability of tomato juice to reduce the toxicity of copper compounds against *Didymella* may account for the failure to control the

Table 1.

Effect of chemical compounds on spore germination.

Solution	*Spore germination in tomato juice*					
	In solution		*Treated for 1 hour*			
			Centrifuged and drained		*Centrifuged and washed*	
	Germination	*No germination*	*Germination*	*No germination*	*Germination*	*No germination*
Copper sulphate	—	1:100	1:10	—	1:10	—
Copper nitrate	1:100	1:20	1:10	—	1:10	—
Copper chloride	1:100	1:20	1:10	—	1:10	—
Cheshunt Compound	—	1:100	1:100	—	1:100	—
Potassium cupri citrate B alkaline	1:100	1:20	1:20	1:10	1:20	1:10
Zinc sulphate	1:1,000	—	1:1,000	—	1:1,000	—
Mercuric chloride	—	1:10,000	—	1:10,000	—	1:10,000
Basic phenyl mercuric nitrate	1:500,000	1:200,000	1:500,000	1:200,000	1:500,000	1:200,000
Basic phenyl mercuric borate	1:700,000	1:500,000	1:500,000	1:200,000	1:200,000	1:100,000
Ethyl mercuric phosphate	1:1,000,000	1:700,000	1:1,000,000	1:700,000	1:500,000	1:200,000
Malachite green	—	1:5,000	—	1:5,000	—	1:5,000
Methic green	—	1:5,000	—	1:5,000	—	1:5,000
Brilliant green	—	1:5,000	—	1:5,000	—	1:5,000
Crystal violet	—	1:10,000	—	1:10,000	1:10,000	1:5,000
Sodium hypochlorite	—	1:1,000	—	1:1,000	—	1:1,000
Lime sulphur	1:250	—	1:250	—	1:250	—
Carbon bisulphide (1:50 emulsion)	—	1:200	1:200	—	1:200	—
Acetic acid	1:500	1:200	1:500	1:200	1:200	1:100
Benzoquinone	—	1:1,000	1:1,000	—	1:1,000	—
Hexamine	1:500	—	1:500	—	1:500	—
Chloramine T	—	1:1,000	1:500	—	1:500	—
Shirlan	—	1:50	—	1:50	—	1:50
Salicylanilide sodium salt	—	1:1,000	1:1,000	—	1:1,000	—
†Tar acid sterilizing fluid	1:2,000	1:1,000	1:50 1:1,000	—	1:50 1:1,000	—
Formaldehyde (40%)	—	1:500	—	1:500	—	1:500

† Inconsistent results were obtained with this compound.

Table 2.

Effect of mercuric compounds and dyes after contact with soil on spore germination.

Solution	*Type of soil*	Weight of soil in grams	Weight of solution in ml.	*Spore germination in tomato juice*					
				In solution		*Treated for 1 hour*			
						Centrifuged and drained		*Centrifuged and washed*	
				+	−	+	−	+	−
Mercuric chloride	from tomato border	100	100	1:1,000	1:750	1:750	1:500	1:750	1:500
Malachite green	,, ,,	100	100	1:500		1:500		1:500	
Methic green	,, ,,	20	100	1:1,000		1:1,000		1:1,000	
Brilliant green	,, ,,	20	100	1:1,000		1:1,000		1:1,000	
Crystal violet	,, ,,	100	100	1:500		1:500		1:500	
Basic phenyl mercuric nitrate	Air dry, maiden loam	100	100	1:5,000	1:3,000	1:7,500	1:5,000	1:5,000	1:2,500
Basic phenyl mercuric borate	,, ,, ,,	100	100	1:5,000	1:2,500	1:7,500	1:5,000	1:5,000	1:2,500
Ethyl mercuric phosphate	,, ,, ,,	100	100	1:25,000	1:20,000	1:25,000	1:20,000	1:25,000	1:20,000

disease with copper sprays since these would become less effective in contact with the tomato plant. Table 1 gives the lowest concentrations tested at which all the spores were killed and the highest concentrations tested at which any spores germinated When spores germinated at the original concentration tested of any compound of which higher concentrations would be impracticable for use on the soil in which tomato plants were growing, no further tests were made and consequently no figure appears in the " no germination " column.

It will be seen from the table that the substances which are most toxic to *Didymella* spores are those containing mercury and certain dyes. These compounds, however, are adsorbed on the soil and a much higher concentration is required to kill spores in the presence of soil than in the original solutions. To determine the concentrations required to kill the spores on the soil, the solutions to be tested first were shaken for an hour with soil and the spores treated with the filtrate. The results are shown in Table 2.

Of the substances tested, that which gave the best results was ethyl mercuric phosphate which gave 100% kill of *Didymella* spores at a concentration of 1:20,000 after being in contact with an equal weight of soil for one hour. Further experiments are being carried out with this compound.

Fungicidal activity in treated soil

Although mercuric chloride and dye solutions lose much of their toxicity after being shaken up with soil, experiments summarised in Table 3 have shown lower concentrations of these compounds to be toxic to *Didymella* spores in the soil than in leachings (see Table 2). Air dry soil from a cucumber bed was sterilised in glass tubes and a pure culture spore suspension added. After shaking, the fungicide solution was added. After 24 hours contact at room temperatures the liquid was decanted and portions of the soil were transferred to agar slopes which were examined later for growth of *Didymella*.

Table 3

Effect of fungicides on *Didymella* spores in the soil

Solution	*Concentration at which Didymella is killed*	*Concentration at which Didymella is not killed*
Mercuric chloride	1:2,000	1:3,000
Malachite Green .	1:2,400	1:3,200
Crystal Violet .	1: 750	1:1,000

In further experiments the fungicide solutions were added to sterilised tubes of soil which were held at room temperature for 68 hours and then washed in two lots of sterile water. A spore suspension was added to the tubes and after two days portions of the soil were transferred to agar slopes. The results are shown in Table 4.

Table 4

Effect of fungicides on *Didymella* spores in the soil after leaching.

Solution	*Conc'n at which Didymella is killed*	*Conc'n at which Didymella is not killed*
Mercuric chloride	1:1,500	1:2,000
Malachite Green	1: 750	1:1,000

These results, compared with those summarised in Table 3 show that soils treated with mercuric chloride retain a considerable amount of their fungicidal activity after leaching whereas soils treated with malachite green lose much of their toxicity after leaching.

Length of time the surface of soils treated with fungicides remain toxic to *Didymella* spores

Fungicides suitable for sterilising the soil were tested to determine how long the surface of the treated soil remained toxic to *Didymella* spores. Wooden boxes 14 x 8 x 6 ins. were filled with soil from a tomato border two days after it had been steamed. The surface of the soil was pressed down lightly and the solutions applied with a fine rose. In one series sufficient liquid was added to wet the soil to a depth of 1 inch and in the other to a depth of ½ inch, 600 and 300 ml. respectively. Two boxes were treated with 40% formaldehyde at a strength of 1 part in 49 parts water and two boxes with tap water. Glass cylinders ¾ inch in diameter were pressed into the surface of the soil and 0.3 ml. of spore suspension in water was put on to the surface of the soil within each cylinder. After 24 hours portions of the surface layer of the soil within the cylinders was transferred to agar slopes which were examined later for *Didymella*. At the same time, strips of tomato stem epidermis bearing pycnidia were pressed on to the surface of the soil and after 24 hours these were washed in tap water and placed in tomato juice on slides. The spores which emerged from the pycnidia were examined for germination. Spores were put on the soil immediately and 3, 7 and 21 days after application of the fungicide. The experiment was repeated using formaldehyde and a proprietary tar acid sterilising fluid at a dilution of 1 in 50. The results are summarised in Table 5.

Table 5

Toxicity of soil surface to *Didymella* spores after treating with fungicides

Series	*Time after treatment at which spores were applied*	*No. of areas treated*	*No. of areas from which Didymella was isolated*					
			Formaldehyde 1:49		*Tar acid fluid* 1:50		*Water*	
			½ *inch*	1 *inch*	½ *inch*	1 *inch*	½ *inch*	1 *inch*
1	Immediately	3	0	0			3	3
	3 days	3	0	0			3	3
	7 days	3	1	0			3	3
	14 days	3	3	3			3	2
2	Immediately	3	0	0	3	3	3	2
	3 days	3	0	0	3	3	3	1
	7 days	3	0	1	3	3	3	3
	14 days	3	1	3	3	3	3	2
	21 days	3	3	3	3	3	3	3

No difference was seen in the germination of spores from the pycnidia from the stem tissue which had been in contact with the soils treated with fungicides compared with those from the control soils.

As tar acid sterilising fluids are known to give some control of the disease under commercial conditions, further experiments were carried out in six inch pots in which 5 ml. of spores suspension were sprayed on to the surface of the soil in each pot with an atomiser (*a*) immediately before and (*b*) after watering the pots with 70 and 140 ml. of the fungicide. After 24 hours, soil from the surface of the pots was transferred to agar slopes. The results are summarised in Table 6.

Table 6

Effect of adding tar acid sterilising fluid to the soil before and after spores

Series	*No. of isolations yielding Didymella*					
	Tar acid sterilising fluid 1:50			*Water*		
	No. of isolations made	*after spores*	*before spores*	*No. of isolations made*	*after spores*	*before spores*
1	12	0	1	6	6	6
2	12	1	5	6	1	6
3	14	2	5	14	14	14

In these experiments some degree of control was obtained with the tar acid sterilising fluid. There was no appreciable difference between the killing of the spores put on the soil before treatment and those put on after treatment when compared with the controls. The washing down of spores to below the surface layer of soil from which isolations were made would account for the small number of isolations yielding *Didymella* from the pots treated with tar acid fluid and water after the spores had been applied in Series 2.

It is concluded that the surface of soil treated with a 1 in 49 solution of 40% formaldehyde remains toxic to free *Didymella* spores up to 7 days after treatment. After 14 days the formaldehyde ceases to be effective. Results obtained with a tar acid sterilising fluid concentration of 1 in 50 are inconsistent but it was less effective than formaldehyde. Spores contained within pycnidia are unaffected by contact with treated soils.

Similar experiments have been carried out in 1946 with ethyl mercuric phosphate solutions and the results have shown that soils treated with this compound remain toxic to *Didymella* spores for considerably longer periods than those treated with formaldehyde.

The effect of formaldehyde vapour on *Didymella* spores

In the Annual Report for 1943 it was shown that free *Didymella* spores were killed when sulphur was burnt in glasshouses. Sulphur dioxide, however, is injurious to plants and irritating to human beings. It was found impracticable to burn sulphur in glasshouses in the vicinity of dwelling houses or near valuable crops and it became necessary to devise an alternative method of fumigation to use under such conditions. Small (Rep. Exp. Res. Sta. Cheshunt 1930) found that formaldehyde vapour generated by pouring a 40% aqueous solution of formaldehyde upon crystals of potassium permanganate killed the spores of leaf mould, *Cladosporium fulvum*. This method was tested against *Didymella* spores using the quantities recommended by Small. Experiments were carried out in a chamber of approximately 1,000 cu. ft. capacity and the formaldehyde vapour was generated by adding 4 fl. ozs. of commercial 40% formaldehyde to 2 ozs. of potassium permanganate in a glass vessel on the floor of the chamber. Drops of spore suspension prepared from infected stems were allowed to dry on glass slides and these were placed in the fumigation chamber. After exposure, drops of dilute tomato juice were added to the spores and the slides were kept in moist chambers. Control slides were kept in the laboratory for the period of exposure.

In the first experiments slides were placed at heights varying from the ground to 9 ft. above the ground and exposed to formaldehyde vapour for 18 hours. No spore germination occurred on any of the slides exposed to formaldehyde vapour, while over 75% of the spores germinated on all the control slides.

In subsequent experiments the slides bearing spores were placed on a bench 3 ft. above the ground and a number of slides removed at hourly intervals after the formaldehyde had been liberated. The spores on the control slides germinated in tomato juice whereas no spores germinated on the slides exposed to formaldehyde vapour from 1 to 24 hours. The results of these experiments show that free spores of *Didymella* are killed by 1 hour's exposure to formaldehyde vapour produced by 4 fluid ozs. of 40% formaldehyde and 2 ozs. of potassium permanganate to 1,000 cu. ft.

The effect of the vapour on spores contained in pycnidia was investigated by exposing strips of epidermis from infected tomato stems to the vapour for 24 hours and comparing the results with those obtained from epidermal strips kept in the laboratory. Germination occurred in spores from all the treated epidermal strips

but in all cases the number of spores which did not germinate was greater than in the control strips. It is concluded that the spores on the surface of the epidermis which had emerged from the pycnidia before treatment were killed by the formaldehyde vapour but spores contained within the pycnidia during the time of exposure were not killed. Thus fumigating with formaldehyde is a satisfactory method of killing free spores left in the houses after the stems have been pulled out and removed from the houses.

At the present time potassium permanganate is in short supply and it is impracticable to use the method described above for large scale fumigation. It was found that a cheaper and equally effective method of treating large houses was to spray the atmosphere with a solution of 1 part 40% formaldehyde in 49 parts water through a fine nozzle at the rate of 1,100 gallons per acre. Experiments were carried out in a 200 ft. house when spores dried on glass slides were exposed for 24 hours both on the ground and 7 ft. above the ground 8 hours after the spraying had been completed. Spores on control slides kept in the laboratory germinated in tomato juice while none of the exposed spores germinated.

In a further experiment, slides bearing spores were exposed for periods of 2 and 24 hours (*a*) in a house sprayed with formaldehyde at the above rate 24 hours after spraying had been completed and (*b*) in a house sprayed with a tar acid sterilising fluid at a concentration of 1 part in 100 parts of water at the rate of 7,500 gallons per acre, two hours after spraying had been completed. Good spore germination in tomato juice occurred on all the control slides kept in the laboratory and slides exposed for 2 and 24 hours in the house sprayed with the tar acid sterilising fluid. None of the spores exposed to formaldehyde vapour germinated.

Where the burning of sulphur is impracticable it is recommended to spray inside the houses with a 1 in 49 solution of commercial formaldehyde at the rate of 1,100 galons to the acre.

3 (b). Experiments on the control of *Didymella lycopersici* by chemical means.

W. H. READ.

Laboratory and field trials have been made with a number of fungicides for the control of Stem-rot of tomatoes caused by the fungus *Didymella lycopersici*. Since it appears that the most serious source of infection in commercial glasshouses is the presence of the fungus in the soil a number of experiments were made to determine if treatment of the surface of infected soil before planting had any effect on the incidence of lesions at, or slightly above soil level.

Methods

Previous experiments in which unsterilised tomato border soils were inoculated by digging in sand-oatmeal cultures of the fungus or an inoculum prepared by scraping diseased tissue from *Didymella* lesions on tomato stems were of little value owing to the inconsistent results obtained. In many cases a negligible number of plants became diseased when grown in the inoculated soil.

The large number of instances where severe attacks of *Didymella* have occurred on nurseries where the soil has been sterilised by steaming, and the comparative absence of losses due to basal attacks on plants grown in unsterilised soils, suggest that *Didymella* in common with many other fungi, grows more vigorously in a soil which has been sterilised by steaming. In view of this the soil in the tomato borders employed for these experiments was steamed before inoculation, the soil being heated to 210°F. and maintained at that temperature for ten minutes.

Three days after the soil was sterilised it was inoculated by watering on as evenly as possible a spore suspension obtained by soaking pieces of diseased tomato stems in water for three hours and then brushing the *Didymella* lesions whilst immersed in water. The surface of the soil was kept moist after inoculation and the holes were dibbed ready for planting prior to the treatment with fungicidal solutions.

In the first trial the fungicidal solutions were applied as uniformly as possible from a can fitted with a fine rose and the dibbed holes were filled with the solutions. The fungicidal solutions employed in the second trial were sprayed to the surface of the soil to ensure that the entire surface was thoroughly wetted. Care was taken to wet thoroughly the sides and bottoms of the holes. In addition, the plants in several plots in the second trial were watered in with solutions of fungicides immediately they were planted out from the pots.

Planting out was done in the usual manner but great care was taken to prevent transference of infected soil from plot to plot on the feet of workers or by splashing when watering. Plants were removed as soon as it was obvious that they were diseased, and examined for *Didymella*.

Experiment 1

In this experiment three plots each containing fifteen plants were laid out in a small glasshouse. Five days after the inoculation of the soil with *Didymella* the following mercuric chloride solutions were applied. Tomato plants were planted out in the normal manner two days after the application of the mercuric chloride solutions.

Plot 1. Mercuric chloride 0.1% solution at ½ gallon per sq. yd.
Plot 2. Mercuric chloride .02% solution at 1 gallon per sq. yd.
Plot 3. Control—no treatment.

Result

The first plants to wilt due to invasion by *Didymella* were observed in plot 3 twenty days after planting out. Nine days later plants in the other plots commenced to wilt and were found attacked by *Didymella*. At the end of the experiment eight weeks after planting, every plant in the untreated plot had become infected and all but one plant in plot 1 and two plants in plot 2 were also affected.

Experiment 2

A glasshouse 100 ft. long by 12 ft. wide was divided into eighteen plots each of six square yards. Eleven treatments were applied to the plots as follows.

Plot No.	*Treatment*
1	Mercuric chloride 0.05% solution—½ gallon per square yard to soil before planting. Plants watered in with 1 pint per plant.
2 and 14	Malachite Green 0.065% solution. Plants watered in with 1 pint per plant.
3 and 12	Tar acid sterilising fluid (emulsion containing 41% phenols) 2%—1 gallon per square yard to soil before planting.
4 and 16	Mercuric chloride 0.05% solution—1 gallon per square yard to soil before planting.
5 and 13	Malachite Green 0.065% solution. 1 gallon per square yard to soil before planting.
6 and 18	Controls—no treatment.
7	Mercuric chloride 0.025% solution. 2 gallons per square yard to soil before planting.
8 and 15	Mercuric chloride 0.05%. Plants watered in with 1 pint per plant.
9 and 19	Formaldehyde (39.8% comml. solution) 2% solution. 1 gallon per square yard before planting.
20	Mercuric chloride 0.05% solution. Plants watered in with 1 pint per plant and given an equal amount four days later.
17	Malachite Green 0.05% solution and Mercuric chloride .025% solution. 1 gallon per square yard before planting.

All the plots with the exception of those treated with formaldehyde (Plots 9 and 19) and the tar acid sterilising fluid (Plots 3 and 12) were planted up the day following the application of the solutions of fungicides. Eighteen plants of the variety Potentate were planted in each plot.

The plots treated with formaldehyde and the tar acid emulsion could not be planted up until twelve days later owing to the phytotoxic nature of these substances. This fact may be of some significance in view of the result obtained in this trial.

The plants were given normal cultural treatment except for the precautions necessary to prevent the possible transference of infected soil from plot to plot.

Results

The first sign of *Didymella* attack was observed three weeks after planting out. When the experiment had to be concluded 10 weeks after planting out the numbers of plants infected with *Didymella* in the plots were as follows.

Plot No.	*Diseased plants*	*Plot No.*	*Diseased plants*
1	3	14	8
2	3	14	8
3	0	12	0
4	10	16	14
5	5	13	5
6	18	18	13
7	11		
8	14	15	15
9	0	19	0
20	11		
17	9		

The outstanding feature of these results is the absence of disease on plants grown in the plots treated with formaldehyde and the tar acid sterilising fluid. Some reduction in the number of plants attacked was given by several other treatments, in particular the application of 0.05% mercuric chloride solution to the soil before planting out combined with its use for watering in the plants (Plot 1), where the plants were watered in with malachite green solution (Plots 2 and 14) and where the soil was treated with the malachite green solution before planting (Plots 5 and 13).

To what extent the delay in planting the plots treated with formaldehyde and the tar acid fluid influenced the result cannot be stated but in view of more recent work it might have had a pronounced effect.

Experiments on Commercial Nurseries

A number of trials with solutions of malachite green and mercuric chloride were made on commercial nurseries. In some of these the solutions were applied to the soil before planting only and in others additional applications were made by spraying the soil and the bases of the stems of the tomatoes after planting. These treatments in all cases failed to give satisfactory control of the disease.

Conclusion

The experiments conducted at the Research Station show that when tomatoes are planted in a soil which is inoculated with *Didymella* after steam sterilisation the proportion of plants attacked by the disease is high. Certain fungicides when applied to the soil may prevent or reduce the loss due to an infected soil. These experiments were made with soils inoculated with the fungus only a short time before treatment with the solutions of fungicides, and more recent work indicates that this may be an important factor.

4. Can tomato plants resist mosaic infection?

I. W. SELMAN.

Tomato growers will be well aware of the infectious nature of the mosaic diseases infecting the tomato crop. The isolation of purified virus preparations by biochemists has tended to lay great emphasis on the infectious nature of viruses, for inoculation of susceptible plants with the pure tobacco mosaic virus results in infection even at dilutions up to 1 part in a thousand million or say 1/25 oz. of virus crystals in 220,000 gallons of water. Much time has been devoted in the past to seeking methods of eliminating sources of infection from the tomato crop, and valuable results have been obtained by the use of virus-free seed, by soil sterilisation and the prohibition of smoking by workers. Nevertheless under general nursery conditions, complete prohibition of smoking in tomato houses has usually been found to be quite impracticable. Neither is there a simple correlation between smoking and the incidence of mosaic in the tomato crop. Growers will be familiar with mosaic-free crops tended by men who smoke freely, and the incidence of disease varies from season to season often independently of any restriction on the use of tobacco.

Data have been collected for some years, which suggest that tomato plants may resist mosaic viruses under certain conditions, particularly when the virus be introduced into a single leaflet or through a small area of the plant surface only. Infectivity tests by scientific investigators are usually made by wiping infective juice on all leaves of a relatively small plant. Infection of plants under nursery conditions clearly occurs in a different way, and it is

under such conditions that evidence may be found to suggest that plants may display quite effective resistance to invasion by the tobacco mosaic viruses. Experimental work has been carried out both on fruiting plants and on young plants in six-inch pots.

An Experiment with Fruiting Plants

Tomato plants variety " Potentate," growing in ten-inch pots were inoculated with a yellow strain of the tobacco mosaic virus when the third truss was in bud and 18 leaves had developed. Details of experimental procedure will be published in the Journal of Pomology. Infective juice at three dilutions was used as inoculum and either a young leaflet (apical leaflet of the 2nd leaf below the apical bud) or a mature leaflet (apical leaflet of the leaf immediately above the first truss) was inoculated. Three levels of potash manuring were included in the experiment.

All precautions against contamination and cross spread were taken for six weeks following inoculation, but after stopping the plants at five trusses no further precautions against cross spread were taken for the remaining five weeks of the experiment. 11 weeks after inoculation, plants showing no visible symptoms of disease were tested for virus infection. The following summary indicates the number of plants found to be virus-free in the several treatment groups :

Number of plants virus-free at 11 weeks

Infective juice diluted x 30	33 plants out of 98 were virus-free
,, ,, x 120	42 ,, 96 ,, ,,
,, ,, x 480	53 ,, 100 ,, ,,
1/3-2/3 oz. Sulphate of potash per pot	58 ,, 118 ,, ,,
2¾-5½ oz. sulphate of potash per pot	39 ,, 117 ,, ,,
Total for all treatments ...	128 ,, 294 ,, ,,

There was evidence that unduly heavy dressings of sulphate of potash tended to increase the incidence of mosaic infection. The heavy dressings applied were larger than those which would normally be applied to plants in pots, but the result does confirm earlier work (see 28th Ann. Rep.).

Inoculation of older leaflets resulted in the earlier appearance of symptoms than where young leaflets were inoculated, but this result may not necessarily be due to the greater susceptibility of

the older leaves. In the latter a greater area of leaf was in contact with virus particles and hence the initial concentration of virus in the plant would tend to be higher.

The total number of plants virus-free in all treatments (43%) was high. It should be remembered that all plants were actually inoculated with infective juice and were grown for 11 weeks with close spacing (300 plants in a house 70 ft. x 13 ft.).

The manurial and cultural factors necessary to produce plants having a high capacity for resisting invasion by tobacco mosaic virus need to be studied at length, and it is not to be supposed that potash is necessarily the factor of greatest importance in this connection. Thus, for example, Spencer† (1937) in an experiment with tobacco plants found that inoculation of a leaf tip with undiluted infective sap did not invariably result in the development of systemic symptoms by the plant. At certain levels of phosphate manuring up to 22% of the plants failed to develop symptoms of the tobacco mosaic disease. Variations in nitrogen and potash levels were without effect in influencing the capacity of the plant to resist mosaic infection in his experiments. Experiments with young tomato plants were therefore commenced, with the object of seeking some empirical data concerning the nutrient levels likely to combine satisfactory plant growth with a high degree of resistance to mosaic infection.

Experiments with young plants

Tomato plants were grown in 6 inch pots in a maiden clay-loam, which was deficient in phosphates and potash. Variations in the nutrient supply were made by varying the amounts of dried blood, superphosphate and sulphate of potash included in the soil.

Experiment 1. 1945, Sulphate of potash

Forty six-inch pots were filled with steamed clay-loam. All pots received 5 gm. dried blood and 5 gm. superphosphate. Sulphate of potash was included at 8 levels and five pots were included in each treatment. Tomato seedlings variety Ailsa Craig, were transferred to the pots when the first foliage leaves appeared on May 18th. On June 1st when 6 leaves had emerged, the first foliage leaf (at the base of the stem) was wiped with juice containing mild tobacco mosaic virus. 1 gm. of fresh leaf containing virus was ground up with water, filtered through cotton wool and made up to 120 ml. with water. This will be referred to as " Dilution x 120." Three plants were found, by test, to be virus free on June 29th, when at the 13 leaf stage. The results are summarised overleaf.

† Plant Physiol, 22, 825.

Gm. sulphate of potash per pot	*Number of plants virus-free*	*Condition at inoculation*
0	0 out of 5	Leaves pale green. Growth slightly reduced by low potash.
0.625	2 ,, 5	
1.25	0 ,, 5	Growth uniformly good Potash without visible effect over this range.
2.5	0 ,, 5	
5.0	1 ,, 5	
10.0	0 ,, 5	
20.0	0 ,, 5	
40.0	0 ,, 5	Leaves dark green. Stunted.

Experiment 2. Sulphate of potash

An experiment similar to that described in Experiment 1 was carried out, but with a potash range between 0 and 6.4 gm. per pot. Blood and superphosphate levels were the same as in the first experiment. Seedlings of tomato (Potentate) were planted on August 11th in the six-inch pots. On August 30th when the plants were at the 6 leaf stage, the lowest leaf on each plant was inoculated with infective juices as before but at dilution x 200. On October 5th 1 plant out of 40 was found to be virus free as follows :—

Gm. sulphate of potash per pot	*No. plants virus free*	*Conditions of plants at inoculation*
0	0 out of 5	Symptoms of potash deficiency beginning to appear on lowest leaf.
0.1	,,	
0.2	1 ,, 5	
0.4	0	
0.8	0	
1.6	0	
3.2	0	
6.4	0	Maximum height and leaf span in this group.

From these two exploratory experiments there emerged some slight indication that plants grown with potash at a low level, but not sufficiently low to induce deficiency symptoms might show resistance to systemic invasion by the tobacco mosaic virus in certain cases. Potash did not appear to be the factor of primary importance in this connection however, and further experiments were made with variations in the level of nitrogen and phosphate supplied, whilst maintaining a relatively low level of potash in the soil.

Experiment 3. Dried Blood

Seedling tomato plants (Potentate) were planted in 6 inch pots of maiden loam to which had been added 0.625 gm. sulphate of potash and 5 gm. superphosphate per pot. The dressings of blood were varied. The lowest leaf of each plant was inoculated with infective juice containing mild tobacco mosaic at dilution x 200 on September 4th when 6 leaves had emerged. The rate of appearance of symptoms was affected by the level of blood applied but only one plant was found to be virus free on October 12th. This plant was transferred to a larger pot and remained virus free until mid-November when it was discarded.

The results were as follows :—

Gm. Dried Blood/pot	*No. of plants showing mosaic (Out of 5)*			*No. of plants virus free*
	Oct. 1	*Oct.* 4	*Oct.* 9	*Oct.* 12
0.313	1	1	3	0 out of 5
0.625	0	3	4	0 ,,
1.25	0	1	3	1 ,,
2.5	1	1	2	0 ,,
5.0	2	5	5	0 ,,
10.0	1	4	5	0 ,,
20.0	4	4	4	0 ,,

There was thus only a slight indication that the group of plants receiving 1.25 gm. dried blood per pot might be more resistant to virus infection than other plants in the experiment. It should also be noted that on September 4th, when the plants were inoculated, the plants in this group had made the best growth as judged by leaf span, stem height and number of expanded leaves. At the lower levels of blood, symptom appearance was definitely slower than where an excess of nitrogen had been applied.

Experiments varying the blood and superphosphate simultaneously were also made. From the meagre data obtained in 1945, work was continued in 1946 to test the effect of combining variations in the physical nature of the soil with fertilisers balanced on lines suggested by earlier work.

Experiment 4. 1946

Three soil mixtures were used for growing plants in the six-inch pots as follows :—

X 2 Peat : 2 Calcareous sand : 1 maiden loam : 1 old soil.

Y 2 Soil (Loam and old soil) : 1 calcareous sand.

Z 5 Soil (Loam and old soil) : 1 short stable manure.

Fertilisers were mixed into the soils as shown in the table below. The numbers of plants remaining virus-free nine weeks after inoculation of the apical leaflet of the lowest leaf of plants at the 6-7 leaf stage are also given. Inoculum was tobacco mosaic virus at dilution x 200.

Treatment	*Soil mixture*	*Gm. per six inch pot.*			*No. of plants virus-free*
		Blood	*Super*	*Pot. sulphate*	
A	X	1.25	5.0	0.625	3 out of 5
B	X	2.5	10.0	1.25	4 ,,
C	X	5.0	20.0	2.5	2 ,,
D	Y	1.25	5.0	0.625	1 ,,
E	Y	2.5	10.0	1.25	3 ,,
F	Y	5.0	20.0	2.5	2 ,,
G	Y	1.25	5.0	0	2 ,,
H	Y	2.5	10.0	0	4 ,,
K	Y	5.0	20.0	0	3 ,,
L	Z	0	5.0	0	2 ,,

From this experiment there was a clear indication that the fertiliser mixture giving high resistance of the lowest leaf to mosaic infection was the following :

2.5 gm. Blood : 10.0 gm. Superphosphate : 1.25 gm. Sulphate of potash per six-inch pot.

It is important to know if the growth of the plant in this mixture was satisfactory from the commercial aspect, and to this end measurements were made of stem height (cotyledons to apical bud), the maximum leaf span and the number of leaves exceeding $\frac{1}{2}$ inch in length, at the time of inoculation.

Revelant data are as follows :—

Potentate seedlings at cotyledon stage planted in six-inch pots ... ... Feb. 11th

Plants measured and inoculated ... Mar. 12th

(Values are means of 5 plants)

Treatment	*Stem height*	*Max. leaf span*	*No. of leaves*
A	7.1 cm.	21.7 cm.	6.6
B	7.3	21.1	5.8
C	6.7	19.4	6.0
D	6.1	21.3	5.8
E	6.6	21.7	6.6
F	5.9	19.8	6.2
G	6.6	21.1	6.2
H	6.8	22.7	6.4
K	6.6	21.3	6.4
L	7.1	21.8	6.0

(10 cm.=3.94 inches)

For plants grown in February and March, these can be considered to be satisfactory, and were in fact sturdy and of good colour.

The composition of the mixed fertiliser giving these results approximates to 1N : 5 P205 : 2 K20. The composition of the mixed base fertiliser recommended for the John Innes potting compost is given as 5. 1N : 6.4 P205 : 9.7 K20. It seems possible that although growth of tomato plants may appear to proceed satisfactorily over a wide range of fertiliser mixtures, the composition and amount of the mixture giving resistance to mosaic infection may be quite narrowly defined.

Experiment 5. 1946

An experiment was carried out to investigate the effect of including slaked lime in the soil mixture. All pots received 2.5 gm.

blood and 10 gm. superphosphate. No potash was added. Soil treatments were as follows :

	Compost	*Gm. slaked lime per pot*	*pH of moist soil 4 weeks after potting*
A	4 Soil: 1 Stable manure	0	6.65
B	,, ,,	2.5	6.71
C	3 soil: 2 stable manure	0	6.85
D	,, ,,	2.5	7.03
E	Maiden loam	0	5.56
F	,,	2.5	6.34
G	4 soil: 1 peat	0	5.84
H	,, ,,	2.5	6.60
J	3 soil: 2 peat	0	6.11
K	,, ,,	2.5	6.67

The pots were filled with the soil mixtures and watered three days before planting out the seedlings. " Potentate " plants with the first pair of foliage leaves emerged were planted on March 22nd. Inoculation with tobacco mosaic virus at dilution x 200 was on April 8th when 6-7 leaves had emerged. The apical leaflet of the 3rd leaf from the base of the stem was wiped three times with a pad of cotton wool soaked in infective juice. On May 10th when the second truss was in flower, the following results were noted :

Number of plants virus-free

Treatment	*No lime added*	*Treatment*	*Lime added*
A	3 out of 5	B	2 out of 5
C	5 ,,	D	2 ,,
E	5 ,,	F	1 ,,
G	3 ,,	H	4 ,,
J	3 ,,	K	5 ,,
Total	19 out of 25		14 out of 25

Thus liming tended to increase the susceptibility of the plant to mosaic infection except where peat had been included in the compost. From the whole experiment 33 plants out of 50 showed resistance to infection, a result which may be associated with the nitrogen—phosphate ratio of the fertilisers used.

This work is of a preliminary nature and work is now proceeding to translate these results for application to the growing of crop plants in the ground.

5. Infection of the Tree Tomato (Cyphomandra sp.) with Potato virus X

Seedlings of Cyphomandra were raised in July under glass and when at the 4-6 leaf stage, plants were inoculated with a number of common glasshouse viruses by wiping the leaves with a pad of cotton wool soaked in infective juice. The plants failed to react to Spotted Wilt, Tobacco mosaic and Enation mosaic, but 26 days after inoculation (in August) plants inoculated with Potato virus X (a constituent of the mixed virus streak disease of tomato) were found to develop a regular mottling on some of the *lower* leaves. Unlike some of the common virus diseases the younger leaves of affected plants failed to show any abnormal symptom, but as the leaves matured a characteristic mottling developed. Growth and development of affected plants were not noticeably retarded.

An affected and a healthy plant were potted in ten-inch pots as growth proceeded and in the following April, when the plants were 2-3 feet in height, were placed in the open against a South wall. The mottled lower leaves of the plant containing Potato virus X, then rapidly developed brownish black necrotic spots, which were 2-3 mm. in diameter.

This is believed to be the first record of infection of Cyphomandra with a virus disease.

6. The reaction of two species of Datura to the Tobacco Mosaic Virus

The use of " test " plants in the identification of plant viruses may be of great importance in the accurate diagnosis of diseased plants received from growers seeking advice. The thornapple has long been recognised to be of value in this connection and many of these plants have been raised at Cheshunt as an aid to this work. There is, however, some disagreement in the literature as to the reaction of this plant to the common tobacco mosaic (see K. M. Smith " Textbook of Plant Virus diseases," p. 242).

Many species of Datura are in cultivation for various purposes, but at Cheshunt the native white-flowered *D. stramonium* has usually been used. A batch of Datura seed received in 1945 from Dr. Kenneth Smith yielded plants of similar vegetative habit but produced purple flowers. Dr. Melville of Kew identified these plants as being *D. tatula*.

Tobacco mosaic virus (Plant Virus Research Station type) was tested on plants of each species. In one experiment the following results were noted, seven days after inoculation of plants with two foliage leaves.

Species	*No. local lesions on cotyledons*	*Total No. local lesions*	*Other symptoms*
D. Stramonium	13.3 per plant	26.3 per plant	No necrosis or with slight veinal necrosis
D. tatula	1.3 per plant	10.3 per plant	Becoming systemic or with veinal necrosis.

Five weeks later all the plants of *D. tatula* were dead following severe systemic necrosis, whereas all plants of *D. stramonium* were growing vigorously without systemic infection.

From this and similar experiments it was concluded that following inoculation with Tobacco mosaic, local lesions appear more rapidly on *D. stramonium* and also in greater numbers, especially on the cotyledons of young plants, than with *D. tatula*. Systemic necrosis tends to develop rapidly in *D. tatula*, frequently resulting in death, whereas in *D. stramonium* systemic infection may never occur.

7. Control of plant diseases by microbial antagonism : progress report.

E. GROSSBARD.

Some fungi, bacteria and actinomycetes produce chemical substances which inhibit the growth of other micro-organisms and in some cases destroy them entirely. Among these antibiotic substances are penicillin and clavatin (clavacin, patulin, claviformin). The success of penicillin in the treatment of human and animal diseases has attracted attention to these substances and it was decided to see if they could be used for controlling plant diseases in the soil.

Organisms producing antibiotic substances live normally in the soil as saprophytes and it seems likely that these substances are already operating in certain soils. It is recognised that the soil microflora generally exerts an influence on the growth of plant pathogens, and the presence of antibiotic substances may be one of the controlling influences.

The ultimate object of these investigations is to effect a control of certain plant diseases by re-inforcing the soil with bulk cultures of the appropriate antagonistic organism capable of producing the

antibiotic substances in the soil. This involves the study of different strains in search of those likely to produce the greatest amount of the antibiotic substances in the soil, and the investigation of soil conditions in relation to the production and persistence of the substances.

The present investigation has been restricted to the use of penicillin and clavatin, both pure and in cultures of the creative organisms, namely *Penicillium notatum* and *Aspergillus clavatus* respectively.

Tests were made upon a range of organisms and the following selected for immediate investigation :—

B. viridilividum, a bacterial pathogen of lettuce, *B. carotovorum*, the common soft rot organism and the fungus *Phytophthora cryptogea*.

Preliminary trials made with penicillin and *Penicillium notatum* were less successful than with clavatin and *Aspergillus clavatus* and so a more detailed examination was made of the latter.

The anatagonistic properties of *Aspergillus clavatus*

It was found by Wiesner, Waksman and others that *Aspergillus clavatus* produces an antibiotic substance of high antibacterial activity against gram-positive as well as gram-negative bacteria. As most plant pathogenic bacteria are gram-negative this antagonist appeared to be a promising subject for further research.

Waksman and Bugie also reported the activity of clavatin against the fungus *Ceratostomella ulmi* (Dutch elm disease). Clavatin is identical with patulin, the antifungal activity of which against species of *Pythium* has been reported by Anslow et al. It has been found here that *A. clavatus* and clavatin are active against *Phytophthora cryptogea*.

Technique

The culture of *P. cryptogea* had been isolated by Mrs. Sheard at this Station.

Qualitative tests

1. Plates were inoculated with *Aspergillus clavatus* and 6 days later a small piece of a culture of *Phytophthora cryptogea* was placed on the same plate.

2. To melted Potato agar a few c.c. of the purified clavatin dissolved in a buffer solution pH 7 were added. Plates were poured and inoculated with *P. cryptogea*.

3. *A. clavatus* was grown in modified Czapek-Dox solution and the metabolic solution sterilized by filtering. A few c.c. of this were added to flasks of carrot broth, and finally the flasks were inoculated with *P. cryptogea*.

Partial to complete inhibition was observed by all three methods and it was evident that the degree of inhibition depended on the concentration of the antibiotic substance in the medium.

B. carotovorum and a number of bacteria responsible for diseases of lettuces were tested and it was found that *B. carotovorum* and *B. viridilividum* were sensitive to pure clavatin and also to cultures of *A. clavatus*.

The culture of *B. carotovorum* was obtained from Mr. W. J. Dowson of the Botany School, Cambridge, to whom our grateful thanks are extended. The culture of *B. viridilividum* was obtained from the National Collection of Type Cultures. It was not pathogenic when inoculated into lettuce of the varieties All the Year Round and Cheshunt Early Ball. Work on *B. viridilividum* was therefore suspended until a virulent culture could be obtained.

B. carotovorum

The standard zonation method (cup or cylinder plate method) as described by Abraham et al., Heatley, and Foster and Woodruff was used. The assay solution was pruified clavatin dissolved in a buffer solution pH 7. Dilutions were 1:5,000 and 1:10,000.

Dilution	*Inhibition*	*Diameter of area of inhibition in mm.*
1: 5,000	Complete	21
1:10,000	Complete	17

The sample of clavatin used in this experiment was of a lower activity than that received several months previously. The figures, therefore, cannot be regarded as final. As soon as a more potent sample of clavatin is available the experiment will be repeated.

Fresh wheat straw as a medium for the production of an antibiotic substance by *A. clavatus*.

As some evidence had been obtained on the antagonistic properties of *A. clavatus* against plant pathogens *in vitro*, introduction of the organism into a given soil was the next step. Theoretically this should be possible as *A. clavatus* is a soil organism.

In an attempt to discover the optimum conditions for the production of the antibiotic substance in the soil, growth of *A. clavatus* on wheat straw was investigated. That this material when incorporated into the soil has a depressing effect on certain root diseases had been reported by Blair, Garrett and others.

Technique

The experiment was made in two ways.

1. 20 gr. of finely chaffed wheat straw were placed in 1,000 ml Erlenmeyer flasks and 160 ml tap water added.

2. Instead of the tap water 160 ml of a 4% glucose solution in tap water was added.

The flasks were autoclaved for 20 minutes at 15 lbs. inoculated with a spore suspension of *A. clavatus* in sterile water and incubated at room temperature. After 14 days the straw was shaken up with 50 ml of sterile water to extract any crude clavatin produced, together with other metabolic products. The extract was assayed by the standard zonation method, *B. coli* being used as the test organism. Seven samples from one bag of straw were taken at random and examined.

Table 1 shows that sterilized wheat straw is a satisfactory medium for the production of an antibiotic substance by *A. clavatus*. It can only be assumed that this is clavatin for isolation and chemical analysis had not yet been made. It is not impossible that another antibiotic substance is present in either the straw water or the straw glucose extract, as antagonistic fungi are known to produce more than one antibiotic substance under varying conditions. If the antibiotic substance should prove on chemical analysis to be clavatin, the straw glucose medium may be used as a cheap medium for the production of clavatin.

Table 1

Assay of the extract from cultures of *A. clavatus* grown on fresh wheat straw.

Medium	*Sample*	*Inhibition*	*Diameter of area**	*pH*
	1	Complete	15	7.27
	2	,,	14	7.19
Straw	3	,,	14	7.16
and	4	,,	17	6.38
water	5	,,	17	6.80
	6	,,	17	6.84
	7	,,	13	7.18
	1	Complete	25	5.74
Straw	2	,,	24	3.94
and	3	,,	23	5.62
4%	4	,,	23	5.62
glucose	5	,,	25	5.74
solution	6	,,	25	5.68
	7	,,	25	5.69

* Mean to the nearest mm of the diameter of the area of inhibition.

The above experiment had been repeated several times. Altogether 1,200 samples were tested. The straw came from one and the same source.

The fungus apparently made use of the cellulose and the hemicellulose of the straw as a source of carbon. The cellulose-decomposing power of *A. clavatus* has not been investigated here, but Norman, working with other species of *Aspergillus*, reported their ability to decompose the cellulose in straw.

The increase in the supply of easily available carbon by the addition of a 4% glucose solution has greatly increased the titre of the antibiotic substance. This points to a relationship between the production and activity of the antibiotic substance on the one hand and the supply of carbon on the other. The influence of pH has not yet been investigated. It is interesting to note that solutions with a higher titre have a lower pH.

For the sake of convenience the extract from the straw water medium is called 2B and that from the straw glucose medium 3B. Both solutions are fairly stable and lose their activity very slowly on standing. Heat resistance is remarkable. The solutions were autoclaved at 15 lbs. for 20 minutes, after which the loss of potency was either very small or absent altogether. When autoclaved for 40 minutes the activity of 2B was destroyed while 3B remained potent though to a lesser degree.

Antibacterial and antifungal activity was tested against the same organisms as those used with purified clavatin. These were sensitive to both 2B and 3B but at different dilutions as compared with clavatin. This indicates that the antibiotic substance present in the two metabolic solutions may be crude clavatin.

Activity against *B. carotovorum*

The technique applied was identical with that used in the tests with purified clavatin, but 2B and 3B were used undiluted and unsterilized. *B. coli* was used as control. The results are given in Table 2.

Table 2

Assay solution	*Organism*	*Inhibition*	*Diameter of the area of inhibition in mm*
2B	*B. coli*	Complete	17
	B. carotovorum	,,	20
3B	*B. coli*	Complete	25
	B. carotovorum	,,	26

Activity against *Phytophthora cryptogea*

Experimental

A quantitative test was made applying Van Luijk's method as modified by Anslow et al. A dilution series was set up in test tubes decreasing by small differences from 1:10 to 1:10.240. Carrot broth was used as diluent. The tubes were inoculated with small identical discs of an eight days old culture of *P. cryptogea* grown on potato glucose agar. Complete inhibition was observed at dilutions of 1:160 with the straw glucose extract and 1:80 with the water-straw extract.

Although it was realised that the concentrations required for complete inhibition of *P. cryptogea* are very high and that it would be difficult to produce and maintain them in the soil, a small scale experiment was set up to investigate any depressing action which *A. clavatus* might exert on the occurrence of " damping off " of tomato seedlings caused by *P. cryptogea*.

Technique

Sterilized chaffed wheat straw to which either water or a 4% glucose solution respectively was added was inoculated with *A. clavatus* incubated for 5 days and then mixed with sterilized soil. This was placed in seed boxes, incubated for 14 days in a heated glasshouse, and then *P. cryptogea* grown in a 3% sand-oat meal medium was introduced. The inoculum was mixed with only one-third of the soil straw compost and placed in the middle of the seed box, while the rest was filled in with the straw soil compost. This localised inoculation was intended to reveal whether *A. clavatus* would exert any inhibitory influence on a heavy and concentrated infection and if it would prevent the spread of the disease into adjacent uninfected soil.

To some boxes the double amount of straw with or without glucose was added. The glucose set was watered weekly with a 4% glucose solution.

The control sets were identical except that the straw was not inoculated with *A. clavatus* and that a few boxes contained only sterilized soil without any straw.

Results

The treated boxes showed at first a low incidence of damping off. The seedlings in the glucose sets and in those boxes which contained a double amount of straw remained healthy for the first fortnight after emergence. Later on those sets which contained no glucose lost most of the seedlings in the inoculated section but spreading into uninfected soil was slight. The attack in the glucose set sand the boxes with the double amount of straw was slight in the inoculated section and spread into the uninfected soil was absent or very slight.

Table 3.

Number of "damped off" seedlings, Percentage of the total.

	Inoculated with A. clavatus				*Controls*				
	30 *gr. straw plus water*	60 *gr. straw plus water*	30 *gr. straw plus* 4% *glucose sol.*	60 *gr. straw plus* 4% *glucose sol.*	*straw absent*	30 *gr. straw plus water*	60 *gr. straw plus water*	30 *gr. straw plus* 4% *glucose sol.*	60 *gr. straw plus* 4% *glucose sol.*
1. Sowing	48.7	26.2	21.6	13.9	73.2	84	90.6	93.6	85.2
2. Sowing	4	3.2	3.2	1.7	40.2	20	25.1	35.1	22.1

The attack in the control boxes was most severe. At the time of the experiment the temperature in the glasshouses was abnormally high and this might account for the severity of the infection. In the inoculated section many seedlings were destroyed at or just after emergence. Spreading into the adjacent uninfected soil was slow at first but became very rapid as the seedlings grew older. It was interesting to note that the attack was more severe in the boxes containing straw than in those containing soil only.

The seedlings were removed and the boxes were well watered over a fortnight, after which a second sowing was made. This time the attack was comparatively mild, the temperature of the houses being considerably lower. Unlike the results of the first sowing the infection in the control boxes containing straw was less severe than in boxes with sterilized soil only. The incidence of damping off in the treated boxes was negligible with little variation between glucose and other sets. In general the seedlings showed symptoms of acute starvation, most severe in the absence of glucose, but this was remedied by a single application of a fertiliser containing

ERRATA.

Page 62, line 17. For absence, read presence.

ADDENDA.

Refer to page 61.

ompared with the controls the rate of growth
d in the sets inoculated with *A. clavatus*.
v conclusions from this first trial but there
incorporation of wheat straw inoculated
y have some depressing effect on the incidence
See Table 3.
has been repeated on a larger scale but results

Composted straw as a medium for the production of an antibiotic substance by *A. clavatus*

Wheat straw was composted on a small scale by the addition of sulphate of ammonia, lime and water. The heap was turned at intervals. Samples were taken and tested after 2 and 6 months.

The results given in Table 4 although preliminary, indicate the following :—

(*a*) Composted straw is inferior to fresh wheat straw as a medium for the production of an antibiotic substance. In the process of composting micro-organisms have apparently used up materials essential for clavatin production. The additional supply of glucose to the composted straw appears to replace some of the essential nutrients lost, hence the presence of the antibiotic substance in low concentration. Although this work was not repeated sufficiently to justify any further discussion, it is interesting to note that workers on biological control have reported that only the addition of fresh in contrast to well-decomposed organic matter suppresses certain root diseases. A possible correlation between these empirical facts and observations may exist.

Table 3

1	2	3	4	5	6
Extractant	*State of division of soil*	*Ratio soil/ solution*	*Period of Extraction*	*Type of Extraction*	*Composition of extractant*
a. Citric acid	2 mm	1:10	8 hours	Shaking	1% in water
b. Acetic acid	1 mm	1:40	Uncertain	Leaching	3% in water
c. Distilled water	2 mm	1:5	8 hours	Shaking	
d. Morgan's solution	2 mm	1:10	½ hour	Shaking	10% sodium acetate 3% acetic acid
e. Truog's solution	1 mm	1:200	½ hour	Shaking	0.196% sulphuric acid 0.3% ammonium sulphate

pH values are :—(*a*) 2.36, (*b*) 2.60, (*c*) 5.35, (*d*) 4.66, (*e*) 3.04.

Table 4.

Assay of the extract from cultures of *A. clavatus* on composted straw

Medium	*After 2 months*		*After 6 months*	
	Growth of A. clavatus	*Inhibition*	*Growth of A. clavatus*	*Inhibition*
Compost and H_2O	Normal Profuse spore formation	None	Normal Profuse spore formation	None
Compost and 4% glucose sol.	Ditto	Mainly complete.	Ditto	Very variable from complete to none*

* Extracts giving complete inhibition showed narrower zones than those from straw which was composted for two months only.

(*b*) The second point of interest arising from this work is the indication that, although the antagonist may grow vigorously as it did on the compost-water medium, no antibiotic substance is formed.

If the application of fresh wheat straw should prove to be essential for the production of antibiotic substances it must be noted that denitrification in the soil can result and must be counteracted by applying additional nitrogen.

Experiments were started to investigate the effect of nitrogenous fertilisers on the formation of the antibiotic substance. Initial results are contradictory. It appears that certain sources of nitrogen such as sulphate of ammonia may have a depressing action, while others are without effect.

Summary

This report deals with an attempt to use the antagonistic relationship of one micro-organism to another as a means of controlling diseases of glasshouse crops. The preliminary character of the work must be emphasised.

The antibiotic properties of a strain of *A. clavatus* were examined. The fungus was found to be antagonistic to *B. carotovorum*, *B. viridilividum* and *Phytophthora cryptogea*.

A. clavatus grows well on sterilised wheat straw with or without the addition of glucose giving rise to an antibiotic substance, presumably clavatin. The metabolic solutions of *A. clavatus* on this medium were tested against the above organisms and found to be active.

A depressing effect on the incidence of "damping off" of tomato seedlings caused by *P. cryptogea* was observed on application of autoclaved wheat straw inoculated with *A. clavatus*. This effect was more marked in the presence of glucose.

Sterilised composted wheat straw proved an unsuitable medium for the production of an antibiotic substance by *A. clavatus*, though the fungus grew very well on this medium.

The strain of *A. clavatus* used for these experiments and the two samples of purified clavatin were most kindly supplied by Messrs. Roche Products, Ltd.

This work has been carried out under a grant from the Agricultural Research Council.

3. ANIMAL PESTS.

1. Red Spider Mite (*Tetranychus telarius*, L.)

R. R. SPEYER and W. J. PARR.

(a) Experiments in early spraying with Petroleum Emulsion

As the outcome of observations recorded in recent years upon the distribution of Red Spider-mite upon plants in Tomato houses during the early part of the growing season, the co-operation of two commercial growers, to whom an expression of gratitude is here tendered, was elicited for experiments to be carried out upon their nurseries.

Owing to the quite abnormally late appearance of mites upon the plants after their period of hibernation, it was only possible to carry out an experiment upon one of these nurseries.

The object aimed at was to test the effect of applying a spray only to a few (up to five) rows of plants on each side of the central path soon after the presence of the mite had been detected through the appearance of feeding-marks upon the foliage, and so to check the initial infestation to an extent which might later obviate the necessity of repeated application of petroleum emulsions to all the plants in a glasshouse.

In the block of houses, each 230 ft. x 35 ft., chosen for the experiment, the "lengthwise" system of planting out had been adopted, so that four centre rows of plants occupied the area immediately below the ridge.

For the purposes of the experiment, this was advantageous, because mites dropping from the ridge after hibernation would tend to fall directly upon the plants in these four rows. That this did, in fact occur, was amply demonstrated by the later progress of infestation in other houses of the block. The variety grown was Potentate.

On 28th May the four centre rows in a house near the centre of the block were sprayed with a proprietary petroleum emulsion at a dilution of 1 part to 100 parts water. Water had been withheld from the roots of the plants for 3 days previously, and was not supplied to them until 4 days after the application. An examination on 1st June showed the presence of some active stages of the mite with some newly laid eggs: in addition, two small patches of infestation were located upon plants in the row adjoining the path upon the east side.

On 5th June the four centre rows were sprayed again, and an application was also made to a single row both upon the East and West sides.

On 20th June, 3 weeks after the first spraying, the infestation upon plants in the sprayed rows was very slight, and except in the case of a single plant, the new foliage developed was quite free of the mite. As far as it is possible to ascertain, no mites were present upon the unsprayed plants in the remaining portion of the house, and certainly no infestation of any magnitude had developed in any area.

The adjoining house on the East side was kept under observation for comparison : in this no treatment was given. Amongst the plants in the four centre rows a moderate to severe infestation had developed by this date, and in places had spread through five rows to the plants in the row adjoining the gutter on each side. By July 19th in spite of application of a spray two weeks previously, the four central rows showed a very severe infestation, and a considerable one had developed throughout this house.

On this date, 7 weeks after application of a spray to just over one quarter of the total number of plants, the degree of infestation was insufficient to necessitate the taking of further measures of control.

Though the success of the results attendant upon this early spraying exceeded the hopes entertained for it, the method has serious drawbacks from an economic standpoint.

First, there is the danger of plants sprayed with petroleum emulsions early in the season developing *Oedema*.

For the requirements of the experiment, it was necessary to give a second application to four rows of plants at an interval of a week after the first, in order to ensure a radical reduction in the initial infestation. The plants in these rows began to develop *Oedema* some 14 days after the second application. Ten days later the plants were examined by Mr. W. H. Read, who has very considerable experience of the symptoms and development of *Oedema* : it was his opinion that, in this case, *Oedema* had not developed to a serious extent, but during July large areas of dried out tissue made their appearance upon lower portions of the stems and upon truss-stalks (mostly those from which the fruit had already been gathered), though secondary infection by *Botrytis* was very slight and very little fruit fell prematurely from the trusses.

No *Oedema* developed in the two rows of plants which received only one application.

Though for practical purposes a single application might well be sufficient to obtain the desired effect, it is evident that some risk is involved, especially when it is realised that, in normal years, the experiment would have to be carried out not later than the end of April.

The second drawback is also connected with the development of *Oedema*. The necessity of withholding water from the roots of a portion of the plants, in each house requiring treatment for a few days both before and after application, would seriously interfere with the system of watering practised upon a nursery.

This could only be obviated by the use of a spray which would not involve the risk of plants developing *Oedema*. At present no such spray, which will give a sufficiently high mortality of the mites or can be applied economically, is available.

(b) Experimental Spraying with Petroleum Emulsions

In continuation of experiments described in the Annual Report for 1943 (pp. 54-56), the effects upon the mite of spraying infested tomato plants with proprietary emulsions to which a small quantity of calcium chloride had been added, and also of making a second application of an emulsion shortly after the first, were observed. The sprays were applied to plants of the variety E.S.1. grown in the ground. The six plots utilised each contained six plants planted out on 4th May from pots in which they had attained a height of 8 inches. On May 25th, when their average height was 20 inches cut tomato leaves severely infested with mites were placed in contact with the foliage of each plant.

The sprays were applied from a six-gallon capacity hand-spraying tank on 14th June, when the average height of the plants was 3 ft. 6 ins. and the foliage of each had become infested nearly or quite up to the leaves immediately round the growing point. In the cases in which the treatment involved two applications (Plots No. IV and V), the second was given 4 days after the first : this is referred to hereafter as "double" spraying. The two proprietary emulsions selected were those which had given the lowest percentage mortality (41% and 45% respectively) of active stages of the mite and were designated as No. 3 and No. 6 in the previous experiments.

From these, it had been established that the application of Petroleum emulsion sprays gives an almost total mortality of eggs and a very high percentage mortality of resting stages of the mite. The comparatively large numbers of active stages, including the adults (20% and 60%), which remain alive after a single application, continue to breed, and their progeny tend eventually to move upwards to the new growth.

A possible, though by no means accurate, method of comparing the effect of the different treatments appeared to offer itself in the recording, after a suitable period of time, of the total number of new leaves formed by the plants in each plot, and the number of those upon which feeding marks of the mite had made their appear-

ance within that period. For lack of a better method as applied to a comparatively large number of plants, this one was adopted, and the results obtained are shown in Table 1.

The six plots received the following treatments :—

Plot I Control, unsprayed.

Plot II Emulsion No. 3, 1:150. Single application.

Plot III Emulsion No. 3, 1:150 with 0.25% calcium chloride. Single application.

Plot IV Emulsion No. 3, 1:150. Double spraying.

Plot V Emulsion No. 6, 1:100. Double spraying.

Plot VI Emulsion No. 6, 1:100 with 0.25% calcium chloride. Single application.

Table 1

Plot No.	*Period after treatment*	*No. of leaves*		*% with feeding marks*
		unmarked	*marked*	
I	3 weeks	16	57	78
II	5 ,,	25	87	78
III	5 ,,	81	29	26
IV	5 ,,	92	23	20
V	5 ,,	76	18	19
VI	5 ,,	92	18	16

The results indicate very roughly :—

(*a*) that a period of 2 weeks elapsed before the infestation upon the plants which received a single application of Emulsion No. 3 (Plot II) attained a severity equal to that upon the unsprayed plants (Plot I).

(*b*) that the initial infestation had been still further reduced by addition of calcium chloride to the sprays (Plots III and VI) and by " double spraying " (Plots IV and V).

(*c*) that single applications of the emulsions to which calcium chloride had been added, gave results closely similar to those obtained by " double spraying."

In a further experiment, sodium chloride at a dilution of 0.5% was substituted for calcium chloride in combination with emulsion No. 3. A considerable quantity of oil was thrown out of emulsion and the results obtained were most unsatisfactory. It is therefore more probable that the presence of calcium chloride in the

spray fluid may cause the particles of oil in emulsion to adhere to the integument of the mites rather than that the increased mortality amongst them is brought about by a partial liberation of free oil from emulsion.

2. The control of Green-fly (*Aphididae*) on Lettuce.

(1) Fumigation with hydrogen cyanide.

It was shown previously (Ann. Rep. 1944, p. 33) that satisfactory control of Aphides on lettuce could be obtained by the use of a proprietary "cyanide" powder distributed upon the path of a glasshouse, provided that the amount of powder employed to every 1,000 cubic feet space would generate a volume of hydrogen cyanide roughly equivalent to that which would be liberated from one-fifth to one-quarter ounce sodium cyanide in the jar method of fumigation.

In confirmation, three fumigations with hydrogen cyanide generated from 1 part by weight of sodium cyanide and 4½ parts by volume of 33% sulphuric acid were carried out in the same glasshouse of 4,800 cubic feet capacity. The plants comprised an almost mature crop of Cheshunt Early Giant lettuce grown in the ground, seedlings and young plants of Cheshunt Early Ball lettuce in boxes and pots and some plants of Nicotiana placed upon staging. The older lettuce and Nicotiana carried infestations of *Myzus solani*, Kalt. The duration of each fumigation was 16 hours.

(*a*) One-sixth ounce sodium cyanide per 1,000 cubic feet space. Temperature range 49°F.-60°F. The fumigation was without effect upon the plants and Aphides, but nearly all adult White-fly upon the Nicotiana were killed.

(*b*) One-quarter ounce sodium cyanide per 1,000 cubic feet space. Temperature range 52°F.-64°F.

The plants showed no trace of injury. Of the young Aphides up to and including the 3rd instar, 83 per cent. were killed, and the majority of 4th instar and mature apterae succumbed. All the 4th instar and mature alatae, on the other hand, survived.

(*c*) One-half ounce sodium cyanide per 1,000 cubic feet space. Temperature range 45°F.-65°F. The foliage of the mature lettuce plants was severely scorched: injury of a less severe nature was caused to the seedlings and pot-plants (including Nicotiana) and subsequently these made good growth. No living Aphides could be found after the fumigation.

Whereas no material effect upon the Aphides was produced with a dosage of one-sixth ounce sodium cyanide, satisfactory control was obtained with one of one-quarter ounce per 1,000 cubic feet space.

Injury to the plants sustained from a dosage of one-half ounce suggests that prolonged fumigation with comparatively high concentration of the gas is attended with risk of injury to the crop.

(2) Effects of hydrogen cyanide upon mature Aphides

The satisfactory results obtained by "cyanide" fumigation, in spite of survival of many Aphides were attributed to the destruction of a very high proportion of young nymphs (see Ann. Rep. 1944, p. 35). There appeared also to be possibilities that (*a*) after exposure to non-lethal concentrations of the gas, the fecundity of the mature insects might be reduced, and (*b*) small amounts of the gas adsorbed upon the leaf surface might be sufficient to poison the young produced by them after the fumigation.

After a fumigation by the jar method, in which one-quarter ounce sodium cyanide per 1,000 cubic feet space was used (see Expt. *b* above), surviving alatae of *Myzus solani* Kalt. were collected at random and transferred to fumigated and unfumigated plants or leaves taken from them. The number of young produced after a period of 4 days was recorded and compared with the number produced by alatae which had not been subjected to fumigation, with the following results:

8 alatae transferred from fumigated to unfumigated foliage produced 65 young (av. 8).

9 alatae transferred from fumigated to unfumigated foliage produced 70 young (av. 8).

9 alatae transferred from fumigated to unfumigated foliage produced 107 young (av. 12).

8 alatae transferred from fumigated to unfumigated foliage produced 59 young (av. 7).

The fecundity of the alatae which survived the fumigation was therefore not reduced, and as the progeny developed normally upon all the plants, it was concluded that sufficient hydrogen cyanide was not adsorbed upon the leaf surface to be lethal to them.

Alatae of *M. solani* bred upon Lettuce in March were exposed to the action of the gas by placing them in an entomologist's "cyanide" bottle at a temperature of 64°F.-66°F. and removing them at intervals to plants or fresh leaves of lettuce. After exposure for from 15-30 seconds the insects were unable to co-ordinate their movements, but recovered within a period of one hour. With exposures of 1 to 1½ minutes movement practically ceased, and of 2-3½ minutes the insects became quite motionless: recovery was effected within a period of 1½ hours.

With exposures of 3-4 minutes the insects recovered within 2 hours, but after exposure of from 5-6 minutes some failed to recover. After 3 days the average number of young produced by the survivors was recorded :

Exposure $\frac{1}{4}$-2 minutes, 10 young.

Exposure 3-6 minutes, 6.5 young.

Control, 7 young.

It was concluded that non-lethal exposure to the gas did not materially affect a reduction of fecundity.

(3) Aphididae—some Observations on Species of *Macrosiphum*.

Macrosiphum gei Koch is a large aphid which breeds upon Abutilon, Carnation, Cyphomantra, Lettuce and less frequently upon tomato in glasshouses at the Cheshunt Station. The winged alatae and wingless apterae are viviparous and reproduction is parthenogenetic. Both forms moult four times during their development which normally occupies a period of some 10 days.

Like a number of other Aphides, the insect has two colour forms, one green, the other red, and in the parthenogenetic generations they breed true to their particular colour. In North America Shull (1925)* has shown that the two are convertible only through the sexual generation which arises in autumn. Sexual forms have not been observed at Cheshunt.

In 1944-1945 the green form occurred on Carnation throughout the winter and spring. On July 9th a migration of alatae took place and many of the small number of apterae which remained upon the plants showed pecularities or deformities of structure. These apterae produced few young, and during August the plants became entirely free of infestation. It was not until the middle of October that alatae returned and began to breed. Large colonies of the insects were confined mainly to plants which had developed flower stalks : upon these the Aphides congregated shortly before reaching maturity. From July to September, Lettuce and Potato growing out-of-doors in the vicinity of the glasshouses became infested.

In February, 1944, considerable difficulty had been experienced in establishing the green form from Carnation upon Lettuce on which the red form had been breeding freely for some time, and it was considered advisable to enquire further into the reasons for this.

From July to December 1945 a series of host-transference experiments were carried out. A very critical examination of the structure of the Aphides employed, and of their progeny, leaves no doubt that all belonged to one and the same species of *Macrosiphum*. The plants to which the insects were transferred were grown in pots

* Shull, A. F., 1925, American Naturalist, LIX., 289-310.

under lamp-glasses covered with muslin, or in large breeding cages. In many instances nymphs in the fourth instar were used, so as to ensure that the mature forms had not given birth to all or to the majority of their young beforehand. It had previously been determined that when living upon lettuce, alatae gave birth on the average to 32 young during their life of 11-15 days : apterae produced on the average about 40 young and lived for about 3 weeks.

The results obtained are here briefly summarised.

Green form

1. 15 Apterae transferred from Carnation to Lettuce. 28-30.vii. None lived longer than 7 days. Of the few young produced, only 5 became mature apterae (developmental period 10-11 days). In the second generation 1 alata and many apterae were produced (developmental period 11 days) and in the third, many alatae and apterae.

(*a*) 12 Apterae of 2nd. generation transferred to other lettuce plants 4.ix, produced many young which developed to alatae and apterae (developmental period 10 days).

(*b*) 9 apterae of 2nd generation transferred from lettuce to young tomato plants 4.ix. Three died within 2 days, 6 wandered from the plants. No young produced.

2. Sixteen apterae transferred from Carnation to Lettuce 18 xii. Eleven died within 9 days without progeny : 5 produced many young which developed to alatae and apterae (developmental period about 12 days).

3. Sixteen alatae transferred from Carnation to Lettuce 18 xii. Nine produced young which developed to alatae and apterae (developmental period about 12 days).

4. Two apterae transferred from Carnation to Potato 14 viii. One produced 9 young which all developed to apterae (developmental period 9 days). These produced many young. The other produced only 1 young which developed to an aptera (developmental period 14 days), and died without progeny.

(*a*) Six apterae of the 1st generation transferred from Potato to Lettuce 4.ix.

All produced many young which developed to alatae and apterae (developmental period 11 days).

In October nearly all the offspring of these developed to alatae.

(*b*) Many young of the 1st generation transferred from Potato to Tomato (young plants) 4.ix.

Only 4 apterae reached maturity and these died without progeny shortly after the final ecdysis.

A few experiments of a similar nature were carried out with the green form collected from Lettuce and Potato.

5. Alata and aptera transferred from Lettuce to Carnation 28.vii. Both produced many young all of which developed to apterae (developmental period 12 days). The progeny of the 2nd and 3rd generations extending into October also developed to apterae.

(*a*) Three apterae of 3rd generation transferred from Carnation to Lettuce 4-7.ix.

All produced many young which developed to apterae (developmental period 10 days). In October many of the progeny developed to alatae.

(*b*) Two apterae of 3rd generation transferred from Carnation to young Tomato plants. 4.ix.

One died without progeny. The other wandered from the plant after giving birth to 3 young, of which two failed to develope beyond the 2nd instar, and one died on reaching the 4th instar.

6. One alata and 5 apterae transferred from lettuce to tomato plants (2 ft. in height) 30. vii-4.viii.

The alata lived for 5 days, during which it gave birth to 5 young, none of which developed beyond the 2nd instar. None of the apterae produced young : three died within 3 days, the other two wandered from the plants.

Other transferences were made from Potato to Carnation plants, but the latter were making no new growth at the time and were therefore not in a condition suitable for breeding the insects.

From the above observations, it would appear probable that the carnation plant, although sometimes subject to severe infestation by *M. gei*, does not supply this species with all its nutritional requirements.

After prolonged breeding upon carnation the mature insects tend to become short lived and are often incapable of giving birth to young after transference to suitable host-plants such as lettuce and potato : in this respect alatae appeared to be less adversely affected than apterae. Frequently from one to three young, ready to be born, were contained within the bodies of mature forms which succumbed before giving birth to them. When young were produced, a large proportion were incapable of successful development, but those which succeeded in reaching maturity gave birth to many young, and normal fecundity was regained by the third generation upon a suitable host-plant.

Of the large amount of material collected it has only been possible as yet to examine a small portion. Measurements of the parents and their progeny in successive generations have been obtained in the case of Experiments No. 1, 4 and 5. The length of the tibia of the posterior pair of legs serves to indicate the general dimensions of these insects: this measurement for the parent and the average for the apterious progeny is shown in Table 2:—

Table 2

Length (in mm.) of hind tibia

Expt. No.	*Transferred from*	*Parent*	*Generation*		
			1st	*2nd*	*3rd*
1	Carnation to lettuce	1.92 (aptera)	2.58	2.58	2.72
4	Carnation to Potato	2.03 (aptera)	2.28	—	—
5	Lettuce to Carnation	2.85 (alata)	1.76	1.74	1.89

There was thus an increase in average size in successive generations after the parent had been transferred from Carnation to Lettuce, but after transference from Lettuce to Carnation the progeny of the 1st generation were much smaller than their parent, and no significant difference was shown in the two succeeding generations.

Attempts to establish the insect on tomato plants 6 inches to 2 ft. in height failed: the aphides usually died within a period of one or two days after transference, with their stylets fixed in the tissues of the stem. The presence of some toxic substance in the sap of the plant is indicated.

Red Form

In May small colonies, comprising alatae and apterae, of the red form of *M. gei* were found upon Tomato on a Cheshunt Nursery. Some of the insects were placed upon pot-plants of Tomato, Turkish Tobacco, and Hyosciamus niger in a breeding cage. In June, an examination of the plants showed that the aphides had made unsuccessful attempts to establish themselves on the two former plants, but that apterae were breeding upon Hyosicamus. A stock was raised on Hyosciamus and during July alatae made their appearance in the colonies. Alatae and apterae transferred to Carnation produced very few young which failed to develop beyond the second instar. A carnation plant, upon which a flower stalk was developing was placed in a cage with infested Hyosciamus: of the considerable number of young produced by alatae which settled upon and a few apterae which wandered on to the foliage, only six developed slowly to mature apterae. These died without progeny.

Other host transferences made were :

7. Two alatae transferred from Hyosciamus to Potato, 13. vii. Many young produced. Between 21.vii and 25.vii, 16 alatae and 16 apterae matured (developmental period 8 days).

(*a*) Two alatae transferred from Potato to Lettuce 23.vii. Many young produced. Between 1.viii and 7.viii, 2 alatae and 16 apterae matured (developmental period 9 days).

(*b*) Two apterae transferred from Potato to Lettuce 23.VII. Many young produced. Between 1.vii and 7.viii, 21 alatae and 5 apterae matured (developmental period 9 days).

(*c*) Four alatae and 3 apterae transferred from lettuce to tomato (plants 2 ft. high) 7.viii.

All died without progeny, except one alata which gave birth on a low leaf, to 4 young : three of these matured, without moving from the leaflet, to apterae (developmental period 12-16 days). These died without progeny.

There can be no question as to the ability of the red form of *M. gei* to breed freely upon lettuce and potato, but carnation appeared to be ill-suited to establishment of the insect.

If the sap of the tomato plant contains some substance toxic to the aphides, the results obtained in experiment 7*c* might indicate that the distribution of this principle in the tissues of the plant is not always uniform ; further study might throw more light upon this interesting problem and provide some explanation of the comparatively rare occurrence of severe infestations from this and other Aphides upon the Tomato plant.

Movements upon Host-plants

During the experiments, notes were made as to the region of the plant upon which the mature forms produced their young, and upon the movements of the developing nymphs to other parts of the plants.

On Lettuce, the alatae usually gave birth to their young upon the underside of the outer, and therefore older leaves ; the apterae sometimes behaved in the same manner, but more often produced their young at the base of the innermost leaves. After the first moult, the nymphs became dispersed, but the 3rd instar nymphs sometimes arranged themselves in line along the subsidiary veins of older leaves. In the 4th instar, they tended to move to more exposed positions where less moist conditions prevailed.

On Potato, the mature Aphides produced their young upon the underside of leaves situated at some distance below the growing point : the young nymphs moved to leaves round the latter, and in one instance assembled together below a fracture accidentally caused

to a leaf-stalk. On some plants the 3rd instar nymphs moved back to the older leaves upon the upper or underside of which they completed their development: on others they assembled together round the main stem where they moulted to the 4th instar and later dispersed to the leaves. Green forms reared upon the same plant with red-forms, which had taken up their position round the main stem, joined the red colony as they reached the 3rd instar. In the 4th instar both red and green forms dispersed to the leaves to perform their final ecdysis.

On Carnation, the mature alatae selected low leaves or the stem below a growing point to deposit their progeny: the apterae, the base of a flower stalk or that of leaves near a growing point. Young nymphs which remained upon older leaves failed to develop; those which moved to leaves round growing points usually survived, and either completed their development here or formed colonies upon flower stalks or buds after they had reached the 3rd or 4th instar. In one instance a number of mature apterae which had been reared on Potato collected together for a short time upon the cotyledons of young tomato plants to which they had been transferred. When placed upon tomato plants the insects were always restless, and after wandering over the foliage usually died while sucking upon the stem or upper surface of leaflets. When wandering over Tomato and Tobacco, the legs of the insects became clogged with a brown viscous substance.

These observations would suggest that the insects move to positions upon the plants where they can obtain either the maximum amount or a particular form of nutriment suitable to the various stages in their development, and that there may be some variability in the distribution of their requirements both in the type of plant and in individual plants of the same type upon which they are living.

Nomenclature of Aphididae

Macrosiphum gei Koch :—Hille Ris Lambers (1939) regards *M. gei* Kock and *M. euphorbiae* Thomas (=*solanifolii* Ashm.) as distinct species, the former confined to Geum and Umbelliferae, the latter inhabiting a wide range of host-plants which include Geum. From his descriptions it would appear that the two species are separable from one another upon differences in a considerable number of morphological characteristics. An examination of the progeny bred from individual specimens which agree in all particulars with the description given by this author for "*euphboriae*" has shown that not one of these characteristics is of sufficient constancy to be of any diagnostic value in separating this species from *M. gei* Koch.

Through the kindness of Mr. J. P. Doncaster, specimens of *Macrosiphum* collected from Geum at Harpenden, Herts, in June 1944 became available for examination. Of the mature insects, comprising 6 alatae and 5 apterae, two apterae possess all the characteristics of "*euphorbiae*," and the remainder approach "*gei*" in one or more of the characteristics designated for that species, but neither the alata nor the aptera which approach "gei" most closely, possesses all the characteristics prescribed for the latter species. There is a distinct gradation (but still an overlapping one) in size amongst the specimens, the largest tending most towards "*gei*" and the smallest to "*euphorbiae*" in morphological characteristics.

Out of 12 nymphs of the 1st instar collected with the specimens, the caudae of three are beset with three pairs of setae, and of the remainder with two pairs, the latter being the normal number for "*euphorbiae*." Although these observations do not prove that only one species is involved, for the present it is considered best to regard *M. gei* Kock and *M. euphorbiae* Thms. as one and the same species.

Reference. Hille Ris Lambers, 1939 Tenmninkia IV. Leiden.

(4) Onion Thrips (*Thrips tabaci*, Lind.)

Thrips tabaci is a Thysanopteron of very wide distribution, and a pest of economic importance upon many glasshouse plants.

Reproduction is usually parthenogenetic and the occurrence of males is extremely rare. It would appear that the only previous record of males in Great Britain relates to specimens collected by D. G. Morison in the North of Scotland during August 1932 (Speyer 1934 p. 147). It is therefore remarkable that males were found in October 1944 upon leeks grown out-of-doors at the Cheshunt Experimental Station. The insect was breeding in profusion upon these plants at the time, and it was considered possible that the approach of winter and falling temperatures might have been responsible for the appearance of the male sex. This, however, was evidently not so, for during May 1945 males were again in evidence upon the plants.

The specimens obtained agree in all essential morphological characteristics with a male from Scotland and another collected by Prof. H. M. Harris from Onion at Ames, Iowa, U.S.A. in 1931.

Reference. Speyer, E. R., 1934. Ann. Appl. Biol. 21, No. 1. 120-151.

(5) Root-knot Eelworm (*Heterodera marioni*, Cornu.)

A 1% solution of sodium ethyl xanthate, kindly supplied by Messrs. T. and A. Wardle, Ltd., of Leek, was applied on 1st May to the soil of a small plot known to be infected with Root-knot Eelworm, at the rate of 6 gallons per square yard : a similar plot to which 6

gallons water was applied served as a control. A week later, six plants of Tomato variety E.S.1. with an average height of 6 inches, were planted in each plot. On 22nd May the average height of the plants in the treated plot was 9 inches, as compared with 19 inches in the control, and the former were replaced with plants 16 inches tall. It was not until July that these plants began to make satisfactory growth.

The roots of all the plants were examined on 4th October. Those of the control were heavily infested with large nodules, while those of the treated plot bore a considerable number of smaller nodules. It was concluded that sodium ethyl xanthate was unlikely to protect the roots of Tomato plants from infection if applied to the soil at a dilution which would not subsequently involve risk of injury to them.

Chemical Problems.

O. OWEN.

1. General.

An important feature of the advisory work carried out during the year has been the number of cases of yellowing of tomato foliage as a result of magnesium deficiency. This problem was dealt with in some detail in the Report for 1944 and an account of some experiments during 1945 is given later in this section.

The reappearance of sodium chlorate weed-killer on the market after an absence of some years led us to expect reports of chlorate injury to economic plants and during the autumn two such cases were recorded.

Beyond this the advisory work was of the usual type and calls for no comment.

2. The use of muriate in place of sulphate of potash.

The effects of these two treatments on the chloride concentration in the soil have been followed as in previous years. The results confirm the main conclusion already reported, namely, that the base dressings of muriate produce peak values which fall comparatively quickly when watering takes place and rise again after the first top dressing of muriate, after which they fall to a low level during the season. This low level is depressed to negligible values by the heavy winter flooding.

3. The effects of sulphur and sulphuric acid on the reaction and lime content of a tomato soil.

This year it was decided to determine the effect of a heavy dressing of 1 lb. of sulphur per square yard in addition to that produced by 4 ounces per square yard and by sulphuric acid equivalent to the lower dressing.

Results are shown in Table 1. The different dressings were applied on April 20th.

As in previous years the small dressing of 4 ounces per square yard had little effect on the reaction or on the carbonate of the soil. The sulphuric acid, however, reduced the values of both quantities. Earlier results indicated that while reductions in carbonate content and reaction followed the application of sulphuric acid during the course of the season, both values gradually increased to about the same levels as before the treatment. While this is not now the case it is possible that, unless further sulphuric acid is added, both values will again rise in course of time.

Table 1

Date of Sampling	*Treatment*							
	1 lb. sulphur per sq. yd.		*Sulphuric acid*		*4 ozs. sulphur per sq. yd.*		*Control Untreated*	
	$CaCO_3$	*pH*	$CaCO_3$	*pH*	$CaCO_3$	*pH*	$CaCO_3$	*pH*
Jan. 2nd ...	2.37	7.49	2.82	7.44	2.79	7.50	2.62	7.70
Feb. 6th ...	2.28	7.49	2.65	7.54	2.68	7.58	2.71	7.80
Mar. 5th ...	2.18	7.42	2.66	7.53	2.63	7.34	2.78	7.53
Apr. 6th ...	2.15	7.09	2.65	7.15	2.53	7.22	2.65	7.12
May 2nd ...	1.61	6.60	1.85	6.90	2.39	7.32	2.59	7.85
June 6th ...	1.68	6.68	2.29	7.04	2.33	7.24	2.55	7.76
July 9th ...	1.72	6.80	1.99	6.80	2.08	7.10	2.49	7.25
Aug. 3rd ...	1.39	6.66	1.78	7.23	2.10	7.52	2.21	7.34
Sept. 1st ...	1.29	6.61	1.99	7.47	2.30	7.45	2.49	7.64
Oct. 1st ...	1.70	7.05	2.19	7.49	2.34	7.62	2.47	7.91
Nov. 1st ...	1.66	7.10	1.73	6.99	2.53	7.55	2.70	7.62
Dec. 1st ...	1.47	7.14	1.52	7.04	2.61	7.48	2.55	7.67

The heavy dressing of sulphur effected an appreciable reduction in carbonate and it is the first time that such a pronounced effect has been obtained and maintained for a whole season. A comparatively high carbonate content however still remains and it will be of interest to note how long this persists without further additions of sulphur.

One further point of interest is that this sulphur dressing had no effect on the crop or on the young plants which were planted out ten days after the application.

4. Magnesium deficiency in tomatoes.

Last year it was reported that a 2% solution of Epsom salts in water plus a suitable wetter had been recommended for the correction of this deficiency. Since then this solution has been widely used with satisfactory results.

On two commercial nurseries plants receiving this treatment have been compared with control plants and with those in plots dressed with Epsom salts before planting.

In Nursery ' A ' the yellowing had gradually become more acute in succeeding years. Plots were arranged so that—

2 received 1 ton of Epsom salts per acre before planting ;

2 were to be sprayed as soon as the characteristic yellowing appeared ;

2 were to remain unsprayed.

Plants were planted out March 5/6th and spraying was started on April 23rd when mild yellowing was fairly general. Spraying was repeated on May 16th and June 6th. On June 21st affected plants were counted in sprayed and unsprayed plots. Of the sprayed plants none showed any acute yellowing and over 94 per cent. were completely green. Top growth on these plants was definitely sturdier than on those untreated.

Of the unsprayed plants 95 per cent. were acutely affected.

At this stage it was considered that the experiment had served its purpose and it was decided to spray the control plants. This was done throughout on June 22nd and repeated on July 17th. By July 1st most of the plants in the plots which had received the base dressing of 1 ton per acre were showing some yellowing. It was milder than in plants entirely untreated, but it was clear that correction of the condition had not been achieved.

On this particular nursery the owner is arranging to make Epsom salts spraying part of the routine work for 1946.

Nursery ' B ' was in rather a different category. Here the yellowing had been chronic and extremely acute for some years. Spraying had given promising results in 1944 but had not been started sufficiently early and had not been carried out regularly. The owner rather favoured the application of Epsom salts in the base. This had been tried in 1943 and in 1944 but only with partial success. In 1945 a plot was laid down with 15 cwts. of Epsom salts per acre, this being the third year in succession that this dressing had been applied. The remainder of the houses received standard base treatment. Six weeks after planting the yellowing appeared where no Epsom salts had been applied and the majority of the affected plants were sprayed, a few rows remaining untreated as controls. Thereafter until the end of July they were sprayed at fortnightly intervals. On June 1st affected plants were counted. Of the untreated plants all were showing the characteristic yellowing in an acute form. Of 1,800 sprayed plants none were showing acute signs and 43 only were showing any yellowing at all.

Thereafter the control plants, too, were sprayed.

Three weeks after the yellowing appeared in the nursery the plants growing in soil previously treated with Epsom salts started to show the yellowing. As is usually the case under these conditions it was not very acute but developed throughout the crop.

Although it is not possible to record the effect of this treatment on crop yields both growers claimed that crops were substantially higher than in 1944.

The main conclusions to be drawn from these and other experiments are :—

1. That regular spraying with 2% solution of Epsom salts will keep the plants green ;

2. Epsom salts dug into the base before planting merely delays for three or four weeks the appearance of the symptoms which never become as acute as where no salts are used.

Another conclusion, based on observation on a number of nurseries during recent years is that where this yellowing develops it becomes more acute in succeeding years. It is pointed out to growers, therefore, that it is desirable to keep some record of its appearance and extent so that they can decide when it is necessary to take steps to correct it.

5. Trace elements in lettuce nutrition.

Experiments on the effects of omitting boron, iron, magnesium and manganese respectively on Cheshunt Early Giant have been continued.

Boron

The omission of this element causes the most severe effects of all and such effects are produced more quickly than any caused by omission of any of the other elements.

Within ten days of withholding boron the leaves begin to lose colour. Progressively the loss of colour continues on the older leaves until definite areas are practically white. Meanwhile veins retain most of their colour and this often persists when the leaf is almost dead. The colour is maintained for some time in the heart but eventually paleness and necrosis develop until the plant dies.

General stunting of the whole plant is pronounced and the root growth is very limited.

Iron

Omission of this element appears to have little effect on the roots which compare quite favourably with those of plants receiving a complete nutrient supply.

The effects on foliage are not sufficiently pronounced to make visual diagnosis easy. There is a fair amount of crinkling of the foliage and some loss of colour. Necrotic areas appear near the midribs and on the midrib itself, particularly on the upper side near the base. Such areas are ill defined. The foliage generally carries a grey bloom.

Magnesium

Here omission causes serious stunting of the plant and a reduction of root, particularly of the finer roots. Foliage generally is pale in colour, especially on the lower leaves. As the symptoms develop necrotic, areas appear on the lower leaves. A feature of this deficiency which has been observed repeatedly is the lack of symmetry in affected leaves.

Manganese

Features of this deficiency are some stunting, a grey bloom on the lower sides of the leaves and small well-defined necrotic spots near the margins of the leaves. There is little effect on root production. Irregular necrotic areas appear on the midribs and sometimes the ribs are hollow. Some distortion and lack of symmetry occur.

6. Fruit setting hormones.

Of the two compounds 2:4 dichlorphenacetic acid and betanaphthoxyacetic acid it is clear that the use of the former is attended by too many risks to make its commercial use possible. On some occasions concentrations as low as ten parts per million have caused injury to flowers. Consequently more attention has been paid to betanaphthoxyacetic acid and this is the basis of some of the proprietary products now on the market.

With a suitable wetter this compound induces the production of seedless fruit at concentrations as low as 35 parts per million with no injury to flowers or foliage.

With regard to the upper limit of concentration for safety conflicting results have been obtained. In some experiments 50 parts per million have caused appreciable distortion of the plants, while in others 60 parts per million have been innocuous. Accordingly in the following experiments a concentration of 40 p.p.m. has been employed. In these experiments varying types of plants of varying ages have been subjected to the treatment. These have shown that

1. Fruit ripens rather earlier after this treatment.

2. If excessive amounts are used the fruit develops some hollowness.

All plants used for this work were Potentate growing in pots. In one experiment spraying was started on each truss as soon as the last flower was opened and every effort was made to confine the spraying to the particular truss concerned. Control plants were sprayed with water as in the usual practice of overhead damping. The first fruits to colour appeared on the treated plants five days before they did on the controls. When there were sufficient ripe fruits in each treatment 50 were picked from each. The average weights were :—

Treated	88 gms
Controls	81 gms

Fruits were then cut in half and examined for hollowness with the following results :—

	Treated	*Controls*
Showing no hollowness	37	44
Showing slight hollowness	13	6
Showing acute hollowness	0	0

In another experiment spraying was started when the last bloom of the first truss was in flower. After that the plants were sprayed indiscriminately every week until colouring started. Again when sufficient of the fruit had ripened 50 fruits were picked and the same observations as before were made. Results were as follows :—

Weights

Treated	108 gms
Controls	92 gms

	Treated	*Controls*
Showing no hollowness	28	48
Showing slight hollowness	11	2
Showing acute hollowness	11	0

7. The determination of "available" potash and phosphoric acid in tomato soils.

By O. OWEN and P. REES.

The work carried out during the year can be summarised conveniently under the following headings :—

A.—Analytical methods

B.—The ratio
Potash extracted by N/2 acetic acid to
Potash extracted by 1 per cent. citric acid

C.—Conditions of extraction

D.—General conclusions

A. Analytical methods

As far as the determination of phosphate is concerned all that has been necessary has been the translation, so to speak, of the visual comparison of colours as already described to the comparison in the Spekker Absorptiometer. This has been simple and the Spekker is in regular use for this purpose.

With regard to the estimation of potash the perchlorate method still remains the standard of reference. A fair amount of work has been done on the nephelometric determination and we are able to report progress in this direction. Under carefully controlled con-

Table 2

No.	*Mgms. per cent. K_2O extracted by :* A 1% *Citric Acid Solution*	B 0.5 *N Acetic Acid Solution*	*Ratio B:A.*
1	35	87	2.49
2	36	160	4.45
3	13	53	4.08
4	10	38	3.80
5	62	110	1.78
6	11	52	4.73
7	36	76	2.11
8	13	25	1.95
9	9	16	1.78
10	97	175	1.81
11	26	39	1.50
12	43	87	2.01
13	66	69	1.05
14	209	190	.91
15	9	18	2.00
16	135	210	1.55
17	44	63	1.43
18	103	113	1.09
19	92	97	1.05
20	42	91	2.16
21	108	137	1.27

Average Ratio B:A 2.14

ditions reproducible results have been obtained and we have been able to estimate the potassium from a large number of samples by Morgan's Extracting Solution.

B. The ratio

$$\frac{\text{Potash extracted by N/2 acetic acid to}}{\text{Potash extracted by 1 per cent. citric acid}}$$

To test the value of 2.45 already found for this ratio twenty-one soils of different types from various nurseries were chosen at random. Values given in Table 2 show wide fluctuations and range from 0.91 to 4.45. Again the standard error is considered to be excessive and it appears that this relation cannot be used on the lines previously suggested.

C. Conditions of extraction

The results referred to in ' B ' above require that some attempt should be made by way of explanation. It may still be the case that the extracting solutions are attacking different categories of soil potash. At the same time it has to be borne in mind that all the methods of extraction used have, in fact, been carried out in accordance with the recommendations of their sponsors and these are tabulated in Table 3.

Although the variations in col. 2 may have little effect on the amount of potash and phosphoric acid extracted it is clear that the differences in cols. 3 and 4, 5 and 6 will have profound effects on the extent of extraction. Attempts have been made to reduce these differences with the following results.

Acetic acid was diluted until it gave the same titre against standard caustic soda using bromothymol blue as indicator.

Using the same soil/extractant ratios in each case, potash in the same soil was estimated after leaching and shaking respectively.

Leaching

	mgms per cent. K_2O
Citric	37.4
Acetic acid	48.3

Shaking

Citric acid	25.8
Acetic acid	28.9

pH of the citric acid is 2.39
pH of the acetic acid is 2.82
Normality of each acid against NaOH = 1.55 N/10

Here the only variants were the physico-chemical characteristics of the acids themselves. We appreciate that in the matter of elec-

trolytic dissociation citric acid cannot be regarded as a simple acid. Notwithstanding this the values show much more reasonable agreement than those which are found by the original methods.

In another experiment shaking for 8 hours was tested on 1 mm soil using distilled water. 1 per cent. citric acid and N/2 acetic acid with a soil/extractant ratio of 1:10.

Concurrently the same soil was leached by the Rice Williams method. Results were :—

Shaking

	mgms per cent. K_2O	*mgms per cent.* P_2O_5
Citric acid	68	282
N/2 acetic acid... ...	68.2	107
Distilled water ...	36.8	7.18

Leaching

N/2 acetic acid ...	59.5	143

Here the variables are the actual acids and their concentrations and it is difficult to explain the agreement for the potash values and the significance of the results for P_2O_5 is not clear.

Repeated experiments on these lines on other soils failed to show anything like so good agreement for potash, *e.g.*

Leaching

	mgms per cent. K_2O	*mgms per cent.* P_2O_5
1% citric acid	123.5	290
N/2 acetic acid ...	99.5	157
Distilled water ...	68.3	38

Shaking

1% citric acid	76.5	340
N/2 acetic acid ...	125	200
Distilled water ...	66.5	3.0

These results indicate that the potash and phosphoric acid extracted depend on the method of extraction and the acid and its concentration used.

One last experiment may be quoted as a matter of interest. One soil sample yielded the following data :—

	mgms per cent. K_2O
Standard 1 per cent. citric acid	68
N/2 acetic acid (Rice Williams leaching) ...	270

Another lot of the same soil was extracted with 1 per cent. citric acid with a standard 1/10 soil/extractant ratio. The *residue* was then extracted by leaching with N/2 acetic acid as in the Rice Williams method.

Results were :—

Citric acid—68 mgms per cent. K_2O
Acetic acid—31.2 mgms per cent. K_2O

This was quite unexpected. If we assume that the two acids do attack different categories of soil potash it is to be expected that when the citric acid category has been removed acetic acid extraction would involve removal of the second category. On the other hand if we assume that the potash extracted is in the same category for both acids and the extractions are additive then the potash remaining after citric acid extraction should be soluble in acetic acid.

In either case the total extracted by successive treatments should approximate (on the above premises) to that extracted by the more effective extractant—in this case acetic acid. This is not the case, and the bald conclusion is that the citric acid extraction has *per se* reduced the extractibility by acetic acid of that potash which is left.

D. General conclusions

It will be recalled that this work was originally designed to compare some of the chemical methods in use for the determination of the " available " nutrients in tomato soils and it was hoped that it might be possible to find one with sufficient advantages to merit its recommendation. The results obtained suggest that there is no " best " method and it would appear that the method which makes most appeal to the analyst concerned will continue to be used. We venture the view that, providing there is adequate experience of interpreting results as applied to the cultivation of tomatoes under commercial conditions, this means that the tomato industry will be adequately served.

The results referred to here show that values obtained by the different methods are largely arbitrary and may not bear a strict relation to the amounts of nutrients actually taken up by the plant. These results depend very materially on many factors. Among them are :—

1.—Soil type
2.—State of subdivision of the soil
3.—Ratio of soil to solution
4.—Period of extraction
5.—Type of extraction (shaking or leaching)
6.—Concentration of extractant
7.—Physico-chemical characteristics of extractants used.

These factors should be taken into consideration when analyses made by different methods are being compared.

It would appear that the physico-chemical properties of the acids themselves and the physico-chemical changes which take place during the extraction play important parts and fundamental work in this direction might prove profitable.

APPENDIX A.

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APPENDIX B

Manurial Treatment in Tomato experiments

(Except plots in Appendix C)

(1) Lime

All houses with the exception of Plots 5 and 6 in house 4 and house 5 received hydrated lime at the rate of 10 cwts. per acre.

(2) Base Dressing

Houses 7-10 and the cucumber houses were steamed and received sulphate or muriate of potash at the rate of half ton per acre only.

The remaining houses 1-5 received, hoof and horn, bone meal and sulphate of potash each at the rate of half ton per acre.

(3) Top Dressings

Sulphate of potash.—All houses received a first top dressing of sulphate of potash at the rate of 5 cwts. per acre excepting those receiving muriate of potash in Houses 7, 8 and 9.

Fertiliser Mixture.—All houses except plots 1, 2, 5, 9 and 10 received 5 cwts. per acre of a war time mixture every fourteen days at discretion.

Appendix C.

Manures applied in Plots 1-3, and 10-12 in Tomato House 4.

Plot.	TITLE.	Base Manure in Lbs. per sq. yd.				* Top-dressing in Lbs. per sq. yd.		
		Lime.	Stable Manure.	Super-phosphate	Sulphate of Potash.	Super-phosphate.	Sulph. of Ammonia.	Sulph. of Potash.
1	Complete Artificials (I.) without Nitrogen	1.0	—	0.4	0.1	0.5	—	0.2
2	Unmanured	1.0	—	—	—	—	—	—
3	Complete Artificials	1.0	—	0.4	0.1	0.5	0 2	0.2
10	Complete Artificials with Dung	1 0	7	0.4	0.1	0.5	0.2	0.2
11	Complete Artificials without Phosphates	1.0	—	—	0.1	—	0.2	0.2
12	Complete Artificials without Potash	1.0	—	0.4	—	0.5	0.2	—

* The Top-dressing was applied in eight equal instalments.

Appendix D.

Dates of Cultural Operations, 1944—1945.

Crop.	Sown.	Potted into 60's.	Planted out in borders.	First Top Dressing.	First Fruit Picked.	Last Feed Applied.	Last Fruit Picked.
Tomatoes ...	Jan. 3 1945	Jan. 29 1945	Mar. 27 1945	April 18 1945	May 29 1945	July 19 1945	Oct. 2 1945

Month.	Air Temperatures						Grass Temp.			Rainfall				Mean Soil Temperatures		Hygrometer				Bright Sunshine		Barometer
	Mean		Absolute Max.		Absolute Min.		Av. Min.	Absolute Min.		Total Precipitation	No. of Days Ppt'n.	Greatest Fall				Dry Bulb	Depres. of Wet Bulb	Relative Humidity %	Dew Point	Total No. of Hrs.	Daily Average.	
	Max.	Min.	Tem.	Date	Tem.	Date		Tem.	Date			Amt.	Date	1 ft.	2 ft.							
	°F.	°F.	°F.		°F.		°F.	°F.		Ins.		Ins.		°F.	°F.	°F.	°F		°F.			Ins.
January	37.5	27.9	49.0	31st	14.0	28th	24.4	9.0	28th	1.99	15	0.43	18th	36.1	37.7	32.6	1.0	87.9	29.4	43.9	1.42	29.83
February	52.0	38.3	64.0	18th	27.0	23rd	33.6	21.0	23rd	1.52	13	0.52	11th	41.2	41.3	43.9	1.2	90.7	41.2	60.2	2.15	30.07
March	56.7	37.5	70.0	23rd	26.0	2nd	31.5	18.0	2nd	0.73	9	0.37	25th	43 8	44.1	47 2	2.1	85.1	42.7	131.7	4.25	30.28
April	63.2	40.6	81.0	16th	31.0	29th, 30th	35.8	25.0	30th	1.25	10	0.43	26th	52.1	51.0	54.2	4.5	73.2	45.4	168.7	5.62	29.98
May	67.5	47.1	85.0	12th	33.0	1st, 2nd	43.2	26.0	1st	2.64	13	0.62	3rd	56.5	54.9	58.9	5.0	72.6	49.5	183.6	5.92	29.84
June	70.0	50.6	81.0	20th	41.0	27th	46.8	37.0	16th, 27th	1.92	17	0.33	21st	62.6	60.6	63.2	6.0	68.0	52.1	206.6	6.89	29.96
July	74.3	53.9	85.0	14th, 15th	44.0	2nd	50.2	39 0	2nd	3.06	10	1.97	14th	64.3	62.5	66.2	5.4	72.3	56.5	203.3	6 56	29.98
August	72.5	52.2	88.0	4th	45.0	6th, 25th	49.4	41.0	25th	1.01	11	0.51	9th	62.4	61.9	64.7	3 5	81.1	58.4	148.7	4.80	29.84
September	66 1	52.3	77 0	17th	38.0	28th	48.3	32.0	28th	1.99	19	0.63	3rd	59 2	59.6	60 0	2 0	87.8	56.2	66.2	2.09	30 01
October	61.7	44.1	73.0	11th	36.0	6th	38.1	29.0	6th	3.57	9	2 14	23rd	52.5	54.1	55.0	2.3	85.7	50.6	96.0	3.10	30.02
November	50.6	40.4	60.0	4th	27.0	15th	35.7	21.0	15th	0.40	10	0.21	22nd	48.1	49.8	46.8	1.2	91.5	44.3	36.0	1.20	30 01
December	46 0	34.4	54 0	16th	23.0	9th	28.9	16.0	9th	3.39	18	1.02	27th	41.9	44 0	40.7	1.4	87.9	37.2	39.1	1.26	29.74

Total rain for year, 23.47 ins. No. of days precipitation, 154. Total bright sunshine for year, 1380.4 hours.

DIAGRAM SHEWING ARRANGEMENT OF EXPERIMENTAL PLOTS, 1945